LOGGING

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FIG. I. — Map of the United States showing Natural Forest Regions. (U. S. Forest Service.)

LOGGING

THE
PRINCIPLES AND GENERAL METHODS
OF OPERATION IN THE
UNITED STATES

BY

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TO

THE MEMBERS OF THE NATIONAL LUMBER MANUFACTURERS' ASSOCIATION WITH A DEEP APPRECIATION OF THEIR INTEREST IN FORESTRY AND FOREST EDUCATION

PREFACE

This volume has been prepared as a text-book for use in Forest Schools. The subject is broad in scope and an attempt has been made to cover only the more important features of operation; hence the innumerable variations in equipment and method which are peculiar to different forest regions are not included. Of the many minor industries related to logging, only two of the more important are treated, turpentine orcharding and tanbark harvesting.

One of the most difficult and costly features of a logging operation is the movement of the timber from the stump to the manufacturing plant and the chief facilities and methods for doing this are discussed at length, especially logging railroads. The greatest emphasis is laid on features about which there is not much written material available, while engineering subjects such as road surveys and the measurement of earthwork and rock-work are omitted because they are treated in numerous other text-books.

In preparing this volume the author has consulted freely many of the lumber trade journals, especially The Timberman and the American Lumberman; the various publications of the U. S. Forest Service; "Earthwork and Its Cost," by Gillette; articles in numerous periodicals, especially the Forestry Quarterly; and unpublished manuscripts.

Many of the photographs and drawings are original; the others have been secured from various sources and credit for them has been given whenever their origin was known. The data on timberland ownership are from a report on the Lumber Industry by the Bureau of Corporations of the Department of Commerce and Labor. The log rules in the Appendix were taken chiefly from the Woodsman's Handbook, by Graves;

two tables of cubic contents are from the Forestry Quarterly, and one from the Manual for Northern Woodsmen, by Cary.

The author wishes to acknowledge his indebtedness to all who have aided him in any way in the preparation of this volume, particularly to Prof. Samuel J. Record, who assisted in the correction of the manuscript.

R. C. BRYANT.

NEW HAVEN, CONN.
April, 1913.

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CHAPTER I

FOREST RESOURCES

It is estimated that the original forested area of the United States covered 850,000,000 acres and contained approximately 5,200,000,000,000 feet of timber.[1] It comprised five broad types, namely, the Northern, the Southern, the Central, the Rocky Mountain and the Pacific Slope, the approximate boundaries of which are shown in Fig. 1.

The distribution of the original and present forest area is shown in the following table:

Region.	Original forest.		Present forest.			
	Area.	Stand.	Area.	Stand.	Per cent of original area.	Per cent of original stand.
	Million acres.	Billion feet, B. M.	Million acres.	Billion feet, B. M.	Per cent.	Per cent.
Northern	150	1000	90	300	60	30
Southern	220	1000	150	500	68	50
Central	280	1400	130	300	46	21
Rocky Mountain	110	400	100	300	91	75
Pacific Slope	90	1400	80	1100	89	79
	850	5200	550	2500	65	48

The estimated stand of timber in the United States in 1909 was as follows:[2]

[1] Kellogg, R. S.: The Timber Supply of the United States. Cir. 166, U.S. Forest Service, 1909.

[2] Ibid.

Species	Billion Feet, B. M.
Douglas fir	525
Southern yellow pine	350[1]
Western yellow pine	275
Redwood	100
Western hemlock	100
Western cedar	100
Lodgepole pine	90
White and Norway pine	75
Eastern hemlock	75
Western spruce	60
Eastern spruce	50
Western fir	50
Sugar pine	30
Cypress	20[1]
Other conifers	100
Hardwoods	500
Total	2500

Ownership.[2] — The standing merchantable timber in the United States is owned approximately as follows:

Private	75.0 per cent
National Forest	21.5 per cent
Other Federal and State	3.5 per cent
	100.0 per cent

The private stumpage is held, chiefly, in three regions:

Pacific Northwest	46.0 per cent
Southern pine region	29.1 per cent
Lake States	4.5 per cent
Other regions	20.4 per cent
	100.0 per cent

The ownership of the timber lands in the Pacific Northwest is concentrated in a comparatively few hands. Three interests

[1] The Bureau of Corporations of the Department of Commerce and Labor, in its report on The Lumber Industry, Part I, Standing Timber, estimated the total stand of timber to be 2800 billion feet. Among the marked differences were the following:

Longleaf pine	384.4 billion feet
Shortleaf and loblolly pine	152.1 billion feet
Cypress	40.4 billion feet

[2] See the Lumber Industry, Part I, Standing Timber. Bureau of Corporations, Department of Commerce and Labor. Washington, 1913. Pp. 11–24.

control $24\frac{1}{2}$ per cent of all the private stumpage, namely, the Southern Pacific Company, 105,600,000,000 board feet; the Weyerhaeuser Timber Company, 95,700,000,000 board feet; and the Northern Pacific Railway Company, 36,200,000,000 board feet. Twenty holders control 43 per cent of the private stumpage, and thirty-eight interests control 50 per cent.

In the South the holdings are not so large because the stand of timber per acre is much lower than on the Pacific Coast. Extensive logging operations have made conditions unfavorable for amassing large contiguous holdings, and there have not been the large land grants which were common in the West; consequently the timber is held by a greater number of companies. Twenty-nine interests own 16 per cent of the private stumpage; 67 holders, 24 per cent; 159 owners, 33 per cent; and 558 holders, approximately 50 per cent. The sixty-seven largest interests control 39 per cent of the longleaf, 19 per cent of the loblolly and shortleaf, 29 per cent of the cypress and 11 per cent of the hardwood stumpage. It has been estimated[1] that only 1,200,000 acres of yellow pine, containing 18,000,000,000 feet are not held by manufacturers.

In the Lake States, six interests control 54 per cent of the white and Norway pine stumpage, 16 per cent of other conifers and 2 per cent of the hardwoods, and thirty-three interests control 77 per cent of the white and Norway pine.

The detailed holdings in these three sections are shown on page 543 in the Appendix.

The timber in other regions is divided among many owners, controlling a limited acreage. Few holdings in the Northeast aggregate more than 100,000 acres.

COMMERCIAL SPECIES

Douglas Fir. — This species (*Pseudotsuga taxifolia*) is the most important lumber producer on the Pacific Coast and will undoubtedly surpass yellow pine in annual production during the

[1] Estimate by James D. Lacey and Co., Chicago, Illinois. See The American Lumber Industry, Official Report Tenth Annual Convention National Lumber Manufacturers' Association, May 7 and 8, 1912, p. 94.

next decade. The largest manufacturing plants are located on Puget Sound, the Columbia River, and harbors along the Pacific Coast. A large part of the log supply for these mills is floated to market. Great waste, both in the forest and at the mill, characterizes its manufacture. The home market for low grades is limited and the cost of rail transportation across the mountains to the central and eastern part of the United States is prohibitive, except for the best grades; consequently much good material is left in the forest to rot, or is consumed in the refuse burner at the mill. The increased water transport facilities and the cheaper freight rate that will be provided by the Panama canal should be a great stimulus to the closer utilization of this species. The better grades of lumber are exported extensively to Asia, the South Sea Islands and the western coast of South America. Only small quantities find their way to Europe.

Douglas fir grows in dense, almost pure stands in the Pacific Coast region yielding an average of 35,000 to 60,000 feet of merchantable timber per acre, with 150,000 to 250,000 feet on the better stands. Single trees have scaled 60,000 feet. The maximum yield per acre of Douglas fir so far reported was 585,000 feet. This timber grew on the north shore of Puget Sound.

The cut of Douglas fir in 1910 was 5,203,644,000 board feet.

Stumpage has increased in price rapidly during recent years, and large areas are now held by non-operating concerns as investments. Timber could be purchased in 1892 for 10 to 30 cents per thousand feet but is now held at from $2.00 to $3.50 per thousand feet, the price depending on the location and the quality of the timber. During the last two years a number of sales have been made on the National Forests at approximately $3.00 per thousand feet.

Southern Yellow Pine.—There are three species of yellow pine of primary commercial importance found in the southern region; namely, longleaf (*Pinus palustris*), shortleaf (*P. echinata*) and loblolly (*P. tæda*). The lumber manufactured from them is often marketed under the trade name of yellow pine, although it is customary for manufacturers in a longleaf region to sell all

species under the name of "longleaf," while in parts of Arkansas and Louisiana loblolly is marketed as "soft shortleaf." In the Coastal Plain region of Virginia and the Carolinas where loblolly predominates the product is sold under the trade name of "North Carolina Pine." In some of the large eastern markets like New York and Philadelphia yellow pine is often sold under the trade name of "longleaf," or of "shortleaf," the distinction being based on the physical character of the wood. The term longleaf is applied to timbers and lumber having narrow annual rings, while coarse-grained lumber is called shortleaf.

Longleaf is considered preferable for timbers, flooring and places where the maximum strength or wearing quality is desired, while loblolly and shortleaf are regarded with favor for finish and general construction purposes.

The annual production of yellow pine has probably reached its maximum, but a marked decrease is not likely for a few years because many operators will increase their output when other mills shut down because of the exhaustion of their stumpage. Operators estimate that most of the largest mills will be cut out during the next fifteen years.

The yellow pine forests are now the source of most of the lumber utilized in the South, and in the prairie regions of the Middle West. Their products are also shipped in large quantities to New England, Canada, nearly all countries of Europe and to many parts of eastern South America. They are also the chief source of the railroad lumber supplies of the East and South.

The longleaf forests have for many years been the chief source of the world's supply of naval stores.

The manufacture of by-products, such as pulp, and products of distillation from mill-waste and forest-refuse is growing in importance and promises soon to become an important industry.

Longleaf grows largely in pure stands which run from 5000 to 25,000 feet per acre; shortleaf which seldom exceeds 6000 feet per acre occurs with hardwoods on richer soils; virgin loblolly in southern Arkansas is associated with shortleaf in nearly pure pine forests ranging from 5000 to 30,000 feet per acre, the former comprising from 60 to 80 per cent of the total

stand. The average stand over large areas does not exceed 10,000 feet. In the Coastal Plain region the second-growth forests of loblolly average from 5000 to 6000 feet per acre with a maximum of 15,000 feet. The choicest longleaf stumpage is found in Calcasieu Parish in southwestern Louisiana, where it commands a higher price than in any other part of the South.

The lumber cut in 1911 was 12,896,706,000 board feet.

Logging has become more intensive during recent years and loggers get from three to five times more timber per acre than formerly. In Louisiana the values show an increase from $3.00 per acre in 1897 to $75 in 1911,[1] and in Virginia "timber rights"[2] show an increase from 40 cents per thousand feet in 1897 to $2.96 in 1908. A table of southern yellow pine stumpage values is given on page 541 in the Appendix.

Western Yellow Pine. — Western yellow pine (*Pinus ponderosa*) is one of the more important merchantable species in the Rocky Mountain region. Its market is largely confined to the territory in which it grows and its chief uses are for general construction purposes and mining timbers.

The stand in the Sierras, where it grows in mixture with sugar pine, Douglas fir, incense cedar and firs, ranges from 2000 to 22,000 feet per acre with an average of about 8000 feet. In Arizona and New Mexico it ranges from 3500 to 15,000 feet per acre. Maximum stands of 40,000 feet per acre have been reported.

The cut of western yellow pine for 1910 was 1,562,106,000 board feet.

Stumpage values per thousand feet for western yellow pine have been approximately as follows:

1906, Sierras, California	$2.00 to 2.50
1908, Plumas National Forest	2.50 to 4.00
1910, Crook National Forest	3.00
1910, Crater National Forest	3.15
1912, Manitou Park Reserve, Colorado	4.00 to 5.00

[1] The American Lumber Industry. Official Report Tenth Annual Convention National Manufacturers' Association, 1912. P. 89.

[2] American Lumberman, Chicago, Illinois, Feb. 18, 1911, p. 40.

White Pine. — White pine (*Pinus strobus*) is of less importance in our lumber markets than formerly. Its manufacture is now chiefly confined to the state of Minnesota which contains the greater part of the remaining stumpage, estimated at 75,000,000,000 feet.

Intensive utilization is practiced, because of the high value of the lumber and the extensive demand for box board material for which this species is especially adapted.

The virgin stands of white pine in Michigan averaged from 10,000 to 75,000 feet per acre, although a yield of 25,000 feet was considered good.

The cut of eastern white pine is decreasing each year, the records for 1910 showing a total of 3,119,741,000 board feet.

Stumpage shows a very marked increase in value during the last thirty-nine years. Michigan white pine lands were sold in 1866 for \$1.00 and \$1.25 per acre, while in 1905 the stumpage ranged from \$10 to \$20 per thousand feet. A list of values for the years 1866 to 1911 in the Lake States is given on pages 539 and 540 of the Appendix.

Western white pine (*Pinus monticola*) grows in Idaho, Montana and Washington and is now being substituted in the markets for eastern white pine. This timber is sold largely outside of the home territory, because Douglas fir and other woods can undersell it in the local markets.

The tree rarely occurs in pure stands, but is associated with western larch (*Larix occidentalis*), western red cedar (*Thuja plicata*) and other firs (*Abies sp.*). It reaches its best development in Idaho, where in mixed stands of the above species ranging from 25,000 to 70,000 feet per acre it comprises from 60 to 70 per cent of the total. An occasional acre contains 130,000 feet. A single tree has yielded 29,800 board feet of lumber. The amount of standing timber has not been reported.

The lumber cut in 1910 was 248,435,000 board feet.

Stumpage values now range from \$3.00 to \$4.50 per thousand feet.

Hemlock. — There are two species now on the market known as the eastern hemlock (*Tsuga canadensis*) and the western hemlock (*T. heterophylla*).

It is only within the last twenty years that eastern hemlock has been regarded as of much value except for its bark, and even to-day the latter commands as high a price as the timber, which i knotty and inclined to be brashy and shaky.

Hemlock grows either in pure forests or associated with other ifers. In Pennsylvania the best pure stands run as high as 00 feet per acre. The average in northern Michigan is 00 feet. In West Virginia, where hemlock occurs in a mixed forest, the average is from 2000 to 3000 feet per acre. The heaviest stands in the Appalachians range between 25,000 and 40,000 feet per acre.

The lumber cut in 1910 was approximately 2,669,424,000 feet.

As late as 1897, hemlock was regarded of little value in Michigan and Wisconsin, and could often be secured for taxes. In 1900 the stumpage price was about 50 cents per thousand feet, while to-day the value ranges from $4 to $7 per thousand feet.

The western hemlock grows in the Pacific Coast forests, associated chiefly with Douglas fir and western red cedar. The lumber is not regarded with favor, although it is superior to that of eastern hemlock. The bark is richer in tannin but it is not used extensively, because there are not many tanning establishments in the region and extract plants have not been developed because high freight rates to eastern points limit the available market. The timber is used for general construction purposes and, to a limited extent in Oregon, for the manufacture of paper pulp.

The yield per acre ranges from 7000 to 30,000 board feet.

The lumber cut for 1910 was approximately 166,705,000 feet.

Some records of the value of western hemlock stumpage are as follows:

1902[1]	$1.00
1906[2]	0.47
1909	1.50

Redwood. — The redwood (*Sequoia sempervirens*) is confined to a narrow belt from 10 to 30 miles wide near the Pacific Coast,

[1] Allen, Edward T.: The Western Hemlock. U. S. Bureau of Forestry, Bulletin No. 33, 1902, p. 28.

[2] Sale of Idaho school lands.

extending southward from southern Oregon to San Luis Obispo County in California. It is associated with Douglas fir, tanbark oak (*Quercus densiflora*), western red cedar and western hemlock. The chief commercial stands are in Humboldt and Del Nort counties in the northern part of California.

The average yield per acre is from 60,000 to 75,000 fe although 100,000 feet per acre is not uncommon. Single a are said to have yielded 1,500,000 feet of sawed lumber, a individual trees have contained 480,000 feet log scale of merchantable timber. The highest stand so far reported is 2,500,000 feet per acre, but the yield in merchantable material was reduced 40 per cent through breakage and other losses. The waste in logging redwood is enormous, because of the massive size of the trees and the brittle character of the timber.

The trees average 6 or 7 feet in diameter, although from 10 to 14 feet is not uncommon, with a maximum of about 20 feet. The clear length ranges from 100 to 200 feet.

The lumber is manufactured in mills located near the forest, hauled by rail to the coast, and shipped by water to distributing points or to market. It is sold along the Pacific Coast, in the Far East, and some high grade lumber is marketed in the central and eastern part of the United States. It furnishes wide boards of excellent quality for panels and interior finish. In the West it is used extensively for tanks, flume boxes, house construction, fence posts, shingles and shakes.

The lumber cut[1] in 1910 was approximately 543,493,000 feet.

There is very little redwood stumpage on the market, because the greater part of the timber is held by companies which are now exploiting it. The stumpage in 1890 was held at about 80 cents per thousand feet but is now valued at from $2.50 to $3 50, with a maximum of $5 per thousand feet.

Cypress. — The commercial range of cypress (*Taxodium distichum*) is confined to a narrow strip of swampy land extending along the Atlantic seaboard from North Carolina to Florida, along the Gulf Coast in Florida, Louisiana and western Mississippi, and up the Mississippi River to southern Arkansas.

[1] This includes the cut of the bigtree (*Sequoia Washingtonia*).

The average stands range from 5000 to 8000 feet per acre, the better ones containing from 15,000 to 20,000 feet while an occasional acre in Louisiana reaches a maximum of 100,000 feet.

It has been stated that at least one-third of the standing cypress is affected with a fungous disease, which causes holes in the wood from one-quarter inch to an inch wide and often several inches long. Timber so affected is called "pecky" or "peggy" cypress. The disease is caused by a species of *Daedalia* which also affects the incense cedar of the Pacific Coast. Decay stops as soon as the tree is cut and manufactured into lumber. Cypress timber on knolls just above the level of the water is usually unsound and the trees are fewer in number than on the wet lands. Sound timber occurs in patches in the forest without apparent regularity. It is difficult to distinguish pecky trees before they are cut. The trees in the Atchafalaya River basin are of larger size and less defective than those in the Mississippi bottoms.

Cypress is a highly durable wood and is especially esteemed for greenhouse construction, certain forms of cooperage, silos, tanks, shingles, interior and exterior finish for buildings, and all purposes where resistance to decay is important.

The lumber cut in 1910 was approximately 935,659,000 feet.

It is a swamp species wherever it occurs in commercial quantities and its exploitation presents numerous problems not found in dry-land logging; therefore, cypress logging for many years was difficult, and in some localities was regarded as impossible; consequently the stumpage was not valuable. It is said that timber could be bought as late as 1876 for 25 cents per thousand feet. A sale of a tract averaging 10,000 feet per acre was made in 1880 at 75 cents per acre. In 1890, stumpage could be purchased for 40 cents per thousand feet and a sale was made in 1894 for $5.25 per acre. There is very little cypress stumpage on the market to-day, because it is largely in the hands of operators. The present prices range from $5 to $5.50 per thousand feet. The increase in value is due to improved methods of power logging.

Eastern Spruces. — There are three species which are found chiefly in Maine, northern New Hampshire, Vermont, New York, West Virginia and North Carolina. They are the white spruce (*Picea canadensis*), red spruce (*P. rubra*) and the black spruce (*P. mariana*). The present stand is estimated at 50,000,000,000 feet, four-fifths of which is in New England and New York.

Spruce occurs in pure stands on the higher elevations, and in mixture with beech, birch, hard maple and eastern hemlock on the lower elevations. It reaches its best form in the mountains of West Virginia at an elevation of from 3000 to 4600 feet. Balsam fir (*Abies balsamea*) is associated with spruce in the northern part of its range and is now marketed with it for pulpwood, without distinction as to price.

Spruce is one of the most valuable species for the production of paper pulp and several million cords of Canadian and domestic spruce are consumed annually for this purpose. In addition it is used for house timbers, clapboards and general construction purposes. The chief home markets are in New England and the Northern tide-water ports.

The following shows the approximate stands in the various states:

	Stands per acre.	
	Average.	Maximum.
	Board feet.	Board feet.
New York	2,000– 3,000	15,000
Maine	3,000– 4,000	15,000–20,000
New Hampshire	3,000– 4,000	40,000
Vermont	3,000– 4,000	15,000
West Virginia	6,000–10,000	60,000

The cut of lumber in 1910 was 1,162,931,000 feet.

Spruce pulpwood stumpage in northern New York is held at from $3.50 to $4 per cord and saw logs at from $1.50 to $2 per standard for well-located timber. Saw timber in New Hampshire is held at from $5.50 to $6 per thousand feet, pulpwood in Maine at from $4 to $4.50 per cord, and saw-log timber in West Virginia at from $4 to $5 per thousand feet.

Western Cedars. — The cedars of the Pacific Coast which are of the greatest commercial importance are the western red cedar (*Thuya plicata*), the yellow cypress (*Chamæcyparis nootkatensis*), Port Orford cedar (*C. lawsoniana*) and the incense cedar (*Libocedrus decurrens*).

Western red cedar is the most important shingle wood in the United States, and is also cut extensively for telephone and telegraph poles. When cut into lumber it is used for car siding and roofing, weather-boarding, pattern-making, boat building, cabinet manufacture and a variety of other purposes where strength is not required.

It seldom occurs in pure stands, but is associated with Douglas fir, western hemlock, western larch (*Larix occidentalis*), the several firs and redwood. The average stand per acre over large areas is from 9000 to 10,000 feet, with maximum stands of 40,000 feet.

Stumpage on Puget Sound is worth from $1.50 to $2 per cord, and saw timber from $3 to $4 per thousand feet. On a five-year sale (1907–1912) made on the Kaniksu National Forest, cedar poles brought $1\frac{1}{2}$ cents per running foot, and saw timber $2 per thousand.

Yellow cypress, which is less widely known in the market, is used for boat building, cabinet work, cigar boxes, lead pencils and interior finish.

It is associated with Sitka spruce (*Picea sitchensis*), western hemlock, and other species of minor importance. It occurs singly, or in small groups, and in Alaska runs from 500 to 2500 feet per acre. Single acres are said to contain 40,000 feet. The stumpage value ranges from $1 to $10 per thousand.

Port Orford cedar is limited in amount and is not marketed extensively. It is a favorite wood for ship building, and is also used for interior finish, outside trim, match wood and cabinet work for which it is especially fitted. It is usually associated with western red cedar, Sitka spruce, western hemlock and Douglas fir. It occurs as single trees, rarely in groups. Sales of private stumpage to small loggers have brought from $3.50 to $4 per thousand.

Incense cedar is not cut into lumber to any extent, because of the excessive taper of the bole, and also because a large percentage of the timber is attacked by a fungus (*Dædalia vorax*) which excavates galleries throughout the wood similar in character to the "peck" in cypress. The timber is used chiefly for fence posts, laths, shingles, cigar boxes, pencil stock, and the best grade lumber for furniture and for mining and irrigation flumes.

It is associated with western yellow pine, sugar pine, Douglas fir, western white pine and white fir (*Abies concolor*). The stand per acre in California ranges from 500 to 2000 board feet per acre. The stumpage value ranges from $2 to $3 per thousand feet.

The lumber cut of western cedars in 1910 was approximately 288,587,000 feet of lumber and 9,167,000,000 shingles.

Sugar Pine. — Sugar pine (*Pinus lambertiana*) is found chiefly in southern Oregon and in California where it is an important commercial tree. It never occurs in pure stands but is found associated with western yellow pine, incense cedar and Douglas fir on the lower limits of its range; and with white fir, red fir (*Abies magnifica*) and the bigtree on the higher elevations. The yield in the Sierras ranges from 2000 to 15,000 feet per acre with a maximum of 60,000 feet. An occasional tree contains 54,000 feet.

Sugar pine is especially prized for the manufacture of "shakes" or split shingles, and is also extensively used for fruit boxes, match wood, sashes, doors and blinds, ship decking and interior trim. The lumber is often substituted for that of eastern white pine. The greater part is marketed locally, but it is also shipped as far East as New England.

The cut in 1910 was 103,165,000 feet. The bulk of the remaining stumpage is in the Sierras in California and ranges in value from $2.50 to $4 per thousand feet.

Lodgepole Pine. — This tree (*Pinus contorta*) is found from Alaska to California and east to Colorado, and is used for mine timbers, fence posts, lumber and crossties. The timber is small and knotty and lumber sawed from it is suitable only for general

construction purposes. It is not in demand for interior finish except in the vicinity of the region where it is manufactured.

Lodgepole pine often occurs in dense pure stands in the Sierras. At high elevations it is frequently associated with Douglas fir, alpine fir (*Abies lasiocarpa*) and other firs.

YIELD PER ACRE IN BOARD FEET, GALLATIN COUNTY, MONTANA[1]

(Cutting to a diameter breast high of 11 inches.)

Type.	Lodgepole pine.
	Board feet.
Creek	5900
Eastern Slope	7200
Western Slope	3800
Northern Slope	7000

YIELD PER ACRE IN BOARD FEET, MEDICINE BOW NATIONAL FOREST, WYOMING[1]

(Cutting to a diameter breast high of 11 inches.)

Type.	Lodgepole pine.			Spruce lumber.
	Ties, 6 inches by 8 inches by 8 feet.	Props.	Lumber.	
Pine forest:	Number.	Linear feet.	Board feet.	Board feet.
Quality I	200	1100	3000	1000
Quality II	130	600	1100	200
Quality III	50	240	550	60
Spruce forest	55	230	700	4700
Average for tract	108	500	1100	500

[1] From Forest Tables — Lodgepole Pine. Circular 126, U. S. Forest Service, 1907, pp. 23–24.

Lodgepole in pure stands ranges between 4000 and 30,000 feet per acre, the average over large areas being about 8000 feet.

The cut in 1910 was 26,634,000 board feet.

The stumpage value on National Forests ranges from $1.50 to $2.50 per thousand board feet.

Western Spruce. — The spruces of importance in the western part of the United States are the Engelmann spruce (*Picea engelmanni*) and the Sitka spruce.

Engelmann spruce, which is of the greater importance commercially, grows at high altitudes often in pure forests. It is frequently associated with alpine fir, western larch, lodgepole pine and western yellow pine.

The timber is sawed into lumber and dimension stock for local construction purposes.

On moist flats and along streams Engelmann spruce and lodgepole pine form stands of from 40,000 to 50,000 feet. On the Pike National Forest the maximum stands are 35,000 feet and the average stands 5000 feet. In the Sopris National Forest in Colorado, the stands of Engelmann spruce and associated species range from 4000 to 20,000 feet per acre, of which the former constitutes from 35 to 75 per cent. The stumpage value ranges from $2 to $3.50 per thousand feet.

Sitka spruce is the chief commercial species of Alaska. It is seldom found in pure stands, except on areas of from 1 to 3 acres on which the stand ranges from 10,000 to 90,000 feet per acre. Individual trees have been reported which contain 25,000 feet. On the lower elevations, which are the only places it grows to commercial size, it is usually associated with western hemlock, western red cedar and yellow cypress.

In Alaska it is used chiefly for box shooks for the salmon industry and for building material.

The stumpage value on the Tongass National Forest is about $1 per thousand feet.

The lumber cut of western spruce in 1910 was approximately 286,981,000 feet, the greater part of which came from Washington.

Other Conifers. — Among the conifers cut in small quantities are the eastern larch (*Larix americana*), now often sold with Norway and white pine, and also made into crossties, posts and poles; the western larch (*L. occidentalis*), manufactured into dimension lumber, ties and posts; eastern red cedar (*Juniperus virginiana*), used chiefly for pencil wood, posts and poles; and a number of pines found in the western part of the country which are of local importance only.

HARDWOODS

The hardwood forests extend south from northern New York through the Appalachian Mountains and from central Wisconsin and Michigan through the valleys of the Mississippi and Ohio rivers to central Louisiana, Mississippi and Alabama, and west to the Great Plains. The chief commercial species are the oaks, sugar maple, yellow poplar, red gum, chestnut, beech, birch, basswood, hickory, elm, ash and cottonwood.

The lumber cut in 1910 of the above hardwoods was 8,615,000,000 feet or 21.5 per cent of the total lumber cut of the country.

Yellow Poplar. — Among the more valuable hardwoods is the yellow poplar (*Liriodendron tulipifera*) which occurs, chiefly, in the rich hardwood forests of Virginia, West Virginia, Tennessee, North Carolina and Kentucky. It is used chiefly for weatherboarding, interior finish, furniture, bodies of automobiles and carriages, wagon boxes, woodenware, box boards and paper pulp. Wide boards command a high price for panels and shelving.

The average stand per acre is seldom more than 2000 feet. The timber in Kentucky and Tennessee in 1890 was held at 60 cents per thousand feet but it now commands a stumpage price of from $8 to $12 per thousand feet.

The cut in 1910 was 734,926,000 board feet.

Oaks. — White oak (*Quercus alba*) is the most valuable of the numerous oaks and the best timber comes from the Appalachian region. The wood is used principally for high grade furniture, cooperage stock, car frame material, flooring, interior finish, agricultural implements, and crossties for railroads.

Several species belonging to the white oak group are now marketed as white oak, although but few show the fine radial markings of *Quercus alba.* White oak stumpage values range between $6 and $12 per thousand feet.

The red and black oaks are indigenous to the same region as the white oaks and are now used extensively for cooperage, interior finish, car frame material, furniture and many other

uses where strength is desirable. They are not as durable as the white oaks but large quantities are treated with chemical preservatives and used for crossties.

The stumpage is valued at from $3 to $6 per thousand.

The cut of oak lumber of all kinds in 1911 was 3,098,444,000 feet.

Maple. — Lumber is manufactured from several species, namely, the hard maple (*Acer saccharum*), the black maple (*A. nigrum*), the red maple (*A. rubrum*), the silver maple (*A. saccharinum*) and the Oregon maple (*A. macrophyllum*). The hard and the black maples produce the most valuable lumber, which is cut chiefly in Pennsylvania, the Lake States, New York, West Virginia, Ohio, Indiana and some of the southern and New England States. The lumber is prized for flooring and furniture and is also used for woodenware and gunstocks. Large quantities of the rough wood are utilized in destructive distillation.

The lumber cut of maple in 1910 was 1,006,637,000 feet.

Maple stumpage in New York is valued at from $2.50 to $5 per thousand feet; in Michigan from $5 to $8 per thousand feet; and in Indiana from $6 to $8 per thousand feet.

Red Gum. — The red gum (*Liquidambar styraciflua*) is largely a tree of the lowlands and is found in the best form and in the heaviest stands along the Mississippi River bottoms in Arkansas, Mississippi, Missouri, Tennessee and Kentucky.

Virgin bottom lands in Missouri contain about 5500 feet per acre of merchantable timber and in South Carolina 4000 feet. Second-growth bottom land in the latter state runs as high as 13,000 feet per acre. The maximum stands in the Mississippi River bottoms seldom exceed 15,000 feet.

Red gum has only recently been an important factor in the hardwood market because the wood warps badly in seasoning. Improved methods of handling and the scarcity of other species have greatly increased its use, and it is now employed extensively for furniture, tobacco boxes, fruit packages, and slack cooperage.

The lumber cut in 1910 was 610,208,000 feet.

Stumpage values in the South range from $1 to $2.50, and in Indiana from $5 to $8 per thousand feet.

Chestnut. — Chestnut (*Castanea dentata*) is widely distributed over the Central hardwood region, although nearly 50 per cent of the entire product is manufactured in West Virginia, Pennsylvania and Virginia. The wood is extensively used for furniture, interior finish, shingles, fencing, telephone poles, veneer backing, slack cooperage and for the production of tannin extract.

Chestnut grows in mixed forests of oak and other hardwoods but the sprout forests are largely pure.

The stand per acre is extremely variable, but averages from 2000 to 6000 feet. Chestnut stumpage ranges from $3 to $5 per thousand feet in the Appalachian region and from $5 to $7 per thousand feet in the sprout forests of Connecticut.

During the year 1910, 535,049,000 feet of lumber and 52,091,000 shingles were manufactured from this species.

Beech. — Beech (*Fagus americana*) is found chiefly in the northern and Appalachian forests associated with maple and birch, but the center of beech lumber production is in Michigan, Indiana and Pennsylvania.

The chief uses of beech are for tool handles, clothes pins, flooring, slack cooperage, veneers and woodenware. Large quantities of rough wood are used for the production of wood alcohol and other products of distillation.

The lumber cut in 1910 was 437,325,000 feet.

Stumpage values in northern New York and at points in the South range from $2 to $3.50 per thousand feet; in Michigan from $3 to $5 per thousand feet; and in the Middle West from $6 to $10 per thousand feet.

Birch. — The commercial distribution of birch is largely confined to the states of Wisconsin, Michigan and Maine and is associated chiefly with maple and beech, in stands running from 3000 to 8000 feet per acre. Paper birch (*Betula papyrifera*) in Maine averages about two cords per acre, with a maximum of fifty cords per acre.

The yellow birch (*B. lutea*) and sweet birch (*B. lenta*) are used largely for furniture, vehicle hubs, tool handles, flooring, interior finish, veneers, cooperage, spool stock and novelties. The paper

birch of Maine is used chiefly for spool stock, shoe pegs and shanks, toothpicks and novelty work.

The lumber cut of birch in 1910 was 420,769,000 feet, of which the paper birch comprised 32,000,000 feet.

Yellow birch stumpage in northern New York is valued at from $4 to $6 per thousand feet with somewhat higher values in the Lake States. Paper birch in Maine is valued at from 75 cents to $2 per cord, the average being $1.50.

Basswood. — This tree (*Tilia americana*) is associated with hemlock and other hardwoods in the northern and Appalachian forests. It is manufactured extensively into siding, rotary-cut veneer, car lining, heading, excelsior, baskets, slack cooperage, furniture backs, carriage bodies, pulpwood, etc. Although not durable it is one of the more valuable hardwoods because of its light weight, and the odorless character of the wood.

The lumber cut in 1910 was 344,704,000 feet. The chief center of manufacture is Wisconsin where nearly 40 per cent of the total output is produced.

Stumpage values range from $5 to $7 per thousand feet for well-located timber.

Hickory. — The present commercial stands of hickory are found in the Appalachian and the Mississippi River regions. There are four species of commercial importance, namely, the big shellbark (*Hicoria laciniosa*), the shagbark (*H. ovata*), the pignut (*H. glabra*) and the mockernut (*H. alba*). The strongest and toughest one is the pignut, although the shagbark is but slightly inferior to it. The big shellbark is of medium quality only, while the mockernut is lacking in toughness, although it is strong.

The manufacture of hickory lumber centers in Tennessee, Arkansas, Kentucky and Missouri. These states now produce more than 50 per cent of the total cut.

Hickory occurs singly among other hardwoods. The stands over large areas frequently range from 200 to 400 board feet per acre.

About 65 per cent of the hickory cut is used for vehicle stock, 10 per cent for tool handles, 9 per cent for heavy wagons, 8 per

cent for agricultural implements, and the remainder for novelties of various kinds. About 1,000,000 cords are used annually for fuel. Saplings are sometimes split into barrel hoops, but this practice is less common than formerly.

The lumber cut for 1910 was 272,252,000 feet.

Stumpage prices in the South range from $5 to $8 per thousand feet; in northern Ohio from $15 to $25 per thousand feet; and in eastern Pennsylvania, Maryland and Virginia from $15 to $35 per thousand feet.

Elm. — There are three elms commercially important in the United States, the rock elm (*Ulmus racemosa*), slippery or red elm (*U. pubescens*) and the white elm (*U. americana*), all of which grow in the rich bottom lands along streams. Over one-half of the output is from the states of Wisconsin, Michigan and Indiana. Elm wood is used for hubs, bicycle rims, slack cooperage, coiled hoops, basket splints, etc.

The cut in 1910 was over 265,107,000 feet.

Stumpage values in the South range from $3 to $5 and in Indiana and the Middle West from $8 to $10 per thousand feet.

Ash. — There are numerous species of ash in the United States, but about 60 per cent of the lumber cut is white ash (*Fraxinus americana*), and 30 per cent black ash (*F. nigra*). The greater part of the lumber output is manufactured in the states bordering on the Ohio and Mississippi rivers and also in New York, Pennsylvania, West Virginia and Vermont. Fully one-half of the output is produced in Arkansas, Ohio, Wisconsin, Kentucky, Indiana and Michigan.

It is in especial favor for poles and shafts of wagons and carriages, sporting goods, agricultural implements, hoops and staves for pork barrels, packages and tool handles.

The lumber cut for 1910 was 246,035,000 feet.

In the lower Mississippi bottoms the timber ranges from 2000 to 5000 feet per acre.

The stumpage values in Michigan in 1890 ranged from $1 to $3.50 per thousand feet. To-day they are from $6 to $12 per thousand feet.

Cottonwood. — Several species (*Populus sp.*) are found in abundance and of large size in the bottoms of the lower Mississippi River. The greater part of the annual production comes from the states of Arkansas, Louisiana and Mississippi. It is in demand for boxes, wood pulp, lining for refrigerator cars, excelsior, woodenware and cheap furniture.

The cut in 1910 was 220,305,000 feet, which was the lowest output in many years.

The stumpage in Mississippi is valued at from $1.50 to $3 per thousand feet and in Indiana at from $6 to $10.

Other Hardwoods. — There are many other hardwoods placed on the market, among them tupelo or bay poplar (*Nyssa aquatica*), which is manufactured into flooring, interior finish, planking, and box boards in Louisiana and other Southern States; the cucumber tree (*Magnolia acuminata*), sold largely as yellow poplar; the buckeye (*Æsculus glabra*), manufactured into pulp, interior finish and woodenware; sycamore (*Platanus occidentalis*), used for furniture and plug tobacco boxes; black walnut (*Juglans nigra*); cherry (*Prunus serotina*); and other valuable cabinet woods. These timbers with the exception of tupelo are common to the South Central and Appalachian regions and are associated with the other hardwoods.

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CHAPTER II

PROTECTION OF FOREST PROPERTY

The two great enemies of the forest, fire and wind, have caused the loss of billions of feet of timber. Fire has been the more disastrous, some years destroying timber and other property valued at millions of dollars. Although cut-over lands are still largely neglected, forest-land owners now manifest interest in the protection of their standing timber.

FIRES

The damage from fire is greatest in the coniferous forests of the Northeast, the Lake States, the Inland Empire, and the Pacific Coast, where the stand over large areas is sometimes killed outright, and occasionally almost entirely consumed.

Among the most destructive fires are those which burn in the crowns, leaping from tree to tree. These are difficult to control because they often occur during high winds which fan the flames and carry burning brands for long distances ahead of the main conflagration.

Surface fires, which run along the ground and feed on the litter and undergrowth, are less serious in their immediate results but if the heat is intense they injure the bark and often kill the cambium. The wounds provide excellent places for the entrance of fungi and insects which may render the tree of little value in a few years. The degree of damage depends upon the character and age of the stand. Trees which have thick bark suffer less than the thin-barked species. In the yellow pine region of the South, surface fires run through the forest at frequent intervals, but are seldom hot enough to kill many of the larger trees.

Ground fires are common in the northern forests where organic matter accumulates on the forest floor, sometimes to a depth of

several feet, through which the roots ramify in all directions. The vegetable mold burns slowly, but fires in it are difficult to extinguish and ultimately the soil is consumed and the rocks are exposed. The trees are killed and soon blow down, forming an almost impenetrable slash and a dangerous fire trap. This condition is most pronounced in the coniferous forests of the Northeast, in the Lake States and also in the forests on the Pacific Coast.

BRUSH DISPOSAL

The débris remaining after logging is a source of great danger to standing timber because sparks from locomotives and stationary logging engines often ignite it, during the dry seasons, and when once started fire may spread into the green timber.

Various states[1] have passed laws dealing with the disposal of slash, and private protective associations have also attacked the problem with vigor. The first effective step toward its solution was taken by the U. S. Forest Service when it assumed charge of the National Forests.

The problems concerned with brush handling vary in different forest regions, and even in a given region the proper method of dealing with the situation must be studied for each operation.

In the yellow pine region of the Southwest where the rainfall during a portion of the year is scanty, it often is advisable[2] only to scatter the brush, for the shade afforded by it is conducive to the germination of seed and is beneficial to reproduction. Where it is desired to keep stock away from reproduction the brush is also left undisturbed. If the fire risk is great, the practice recommended by forest officers is to pile the brush in open places and burn it at a period when the fire can be controlled.

In the coniferous forests of New York, a state law provides for lopping the tops and leaving them *in situ*. The weight of the snow during the first winter forces the limbs close to the

[1] Among these are New York, Minnesota, Washington and Oregon.

[2] Woolsey, Jr., Theodore S.: Western Yellow Pine in Arizona and New Mexico. Bulletin 101, U. S. Forest Service, 1911, pp. 53–54.

ground and after three or four years decay largely eliminates the danger from fire. Fires in lopped slash do not become as violent as when the brush is left in the tops to dry out. The cost of lopping in the spruce forests of the Adirondacks ranges from 10 to 15 cents per cord.

Brush burning is recommended for forests where the stand of timber is heavy and the brush dense. These conditions exist in parts of the Lake States, Inland Empire and on the Pacific Coast. The practice is either to pile and burn, or to burn broadcast. Brush can be burned with safety during the wet periods in the spring and fall, after a light fall of snow in the early winter, and in the South during the summer after heavy rains.

Where the aim is to save the seedlings and young timber, brush should be piled and burned. This can be done cheapest at the time of logging because less labor is required for the work, and the removal of the slash facilitates skidding and reduces its cost. In white pine where the brush is dense, the saving in logging expense may be greater than the added cost due to slash burning. As a rule one extra man is required for each 10,000 to 12,000 feet logged. Many lumbermen in the Lake States and the Inland Empire do not log extensively during the danger period in the summer months and hence the above method may be employed to advantage during the greater part of the logging season.

The method followed where brush is disposed of at the time of logging is for the swampers of each skidding crew to select suitable spots where brush can be piled and burned without danger to standing trees and reproduction and where it will not inconvenience the skidding teams. These piles should not be placed nearer than 15 feet to any standing tree. One or more fires are started and the brush as cut is thrown on the nearest blaze. Brush can be burned even during rainy weather and where there is quite a heavy snow, because the latter is shaken off the branches in handling. Studies made by the U. S. Forest Service in Minnesota show that not over 2 per cent of the total acreage of a given operation is burned over when this method is employed.

Piling and burning brush after logging has not proved as satisfactory as the above method, because of the added labor charge. It has some advantages because the piles can be built in the roadways and on skidway sites where there is no timber or reproduction to damage.

In the Minnesota National Forest brush was piled after logging and burned on calm days when the ground was damp. Burning commenced on the leeward side of the cutting. The fires were started in alternate piles in the same row, which left a cold air space between them, lessened the draft and reduced the danger of damage to seedlings and standing timber. When these piles were reduced to embers the alternate ones in the same row were fired. Each successive row was burned in this manner. A sufficient force of workers equipped with fire-fighting apparatus was kept on hand to hold the fires in check. The area burned over by this method was 7 per cent of the total.

A contractor in Minnesota states that in stands composed of equal parts of white pine and Norway pine he has burned brush for 20 cents per thousand during open winters, and 35 cents per thousand during severe winters. The average cost in the region is from 20 to 25 cents per thousand feet.

Hardwood brush is more difficult to burn and costs from 30 to 40 cents per thousand feet in the Lake States when the brush burned is less than 6 inches in diameter.

Broadcast burning is cheaper where protection is desired only for logging equipment and green timber; where the area is clear cut; and in yellow pine forests in the South, where timber is left for a second cutting to be made in fifteen or twenty years. Broadcast burning is the only feasible method in the Douglas fir region because of the great quantities of slash that must be handled. On areas where the stand runs as high as 100,000 feet per acre, the débris is often 10 feet high. The method recommended by a National Forest officer[1] is to burn off at one time areas of from 20 to 40 acres which are selected with reference to topographic features. Burning should begin before large areas

[1] Munger, Thornton T.: The Growth and Management of Douglas Fir in the Pacific Northwest. Circular 175, U. S. Forest Service, 1911, pp. 17–18.

are covered with slash. Back fires should be built around the edge of the strip and around all seed trees.

Early fall burning is recommended because:

(1) Fire in stubs will soon be extinguished by rain.

(2) Some seed trees are liable to be killed and the forest will secure the benefit of the seed crop if the area is burned before the seeds fall.

(3) There will be no summer growth of weeds to check the reproduction the following spring.

(4) On the higher elevations a clear burn cannot be secured in the spring because of moisture conditions.

(5) The hottest fire can be secured in the fall because the brush is then thoroughly dry.

The method recommended by the Chief Fire Warden of Washington for preparing a slashing for broadcast burning consists in felling all large stubs on a strip from 300 to 1000 feet wide on the leeward side of the cutting. Stubs in the green timber are also felled along this line for a distance of from 200 to 300 feet back from the cut-over area, and if the fire danger is great a fire trail is cut in the green timber about 50 feet back of the slashing. The fire is usually started in the afternoon on the leeward side and is allowed to burn back against the wind and toward the center of the clearing. Men are stationed along the green timber to prevent the fire from running into it. If the area is large a fire is started in the center of the cut-over area from three to four hours after the first and allowed to work to leeward. Later a fire is started on the windward side and the remainder of the area burned over.

Débris on steep slopes is burned from the top down to prevent timber on the upper edge from being killed by the intense heat which would result from a heavy fire running up the slope.

In the southern pine region forestry is not practiced at present but it is probable that some lumbermen will soon be interested in logging their virgin timberlands so as to secure a second cut in fifteen or twenty years. Brush disposal is necessary to assure the success of a plan of this sort. Observations and experiments

made in different parts of the region, especially in Arkansas, have demonstrated that broadcast burning offers sufficient protection to timber held for a second cut and can be carried on safely provided all slash is removed for a distance of 10 feet from the timber that is to be left. The slash can be handled by the swampers and occasionally skidding teams can drag whole tops bodily from the vicinity of trees without decreasing the daily output of the skidding crew. The slash should be burned during calm, damp periods, chiefly in the spring and fall, although it may be done on occasional damp days during the hot summer months. If a virgin forest is to be logged during the summer months when broadcast burning cannot be done safely, the practice should be to fire the ground litter in the early spring and thus provide against ground fires running into the slash during the danger season. The slash should then be burned at the first favorable opportunity. The annual ground fires which succeed the burning of the slash will seldom be sufficiently violent to injure the trees held for the second cut, although reproduction often will be killed.

SPARK ARRESTERS

Among the many spark arresters on the market, the following are known to have given the best satisfaction on logging operations:

Sequoia Spark Arrester.[1] — This arrester (Fig. 2) has a ¼-inch mesh wire screen (*A*) which projects above a cinder pan (*B*) attached to the stack. From the cinder pan outlet pipes (*C*) lead to a receptacle below. A light metal deflector is fixed inside the pan to guide the cinders to the outlet pipes. The sparks arrested and deflected by the screen are dropped into the receiving pan. This arrester is used chiefly for wood-burning logging engines. Users claim that the engine exhaust will keep the screen clean and that it does not interfere with the draft. The device is light, and easily put on and removed. The list prices range from $22.50 to $45 each.

[1] Manufactured by the Willamette Iron and Steel Works, Portland, Oregon.

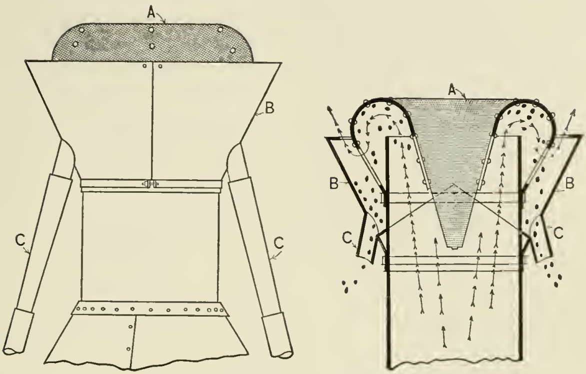

FIG. 2. — The Sequoia Spark Arrester.

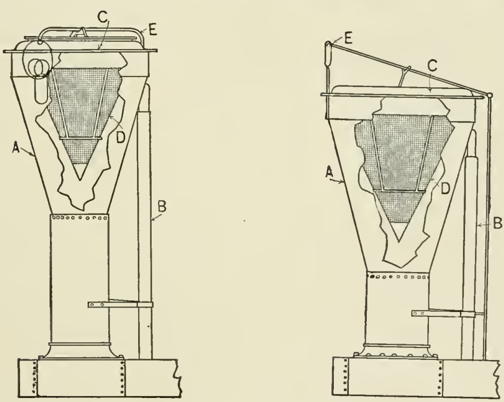

FIG. 3. — The South Bend Spark Arrester. *a*, for logging engines; *b*, for logging locomotives.

The South Bend Spark Arrester.[1] — This type is used extensively in the Northwest. The one shown in Fig. 3*a* is for logging engines and that in Fig. 3*b*, which is built larger and stronger, is for logging locomotives.

[1] Manufactured by the South Bend Spark Arrester Co., South Bend, Indiana.

It has a round tapering shell (*A*) of sheet metal, with an inner wall; an outlet (*B*) at the side for the discharge of sparks and cinders; and a sheet metal cover (*C*). A cone-shaped screen (*D*) attached to the sheet iron cover hangs within the stack, apex downward, and deflects the cinders into the spark receiver at the head of the outlet pipes. The steam, smoke and gas escape through the screen, in which the cinders do not clog because of its conical form. The screen can be raised by means of the lever lift (*E*) when it is unnecessary to use an arrester. The size of arresters for locomotives is governed by the cylinder area, and those for logging engines by the diameter and height of stack used. The list price ranges from $10 to $27 each.

Spark Caps. — A successful spark arrester,[1] Fig. 4, in use by a logging company in Pennsylvania consists of a $\frac{1}{4}$-inch mesh

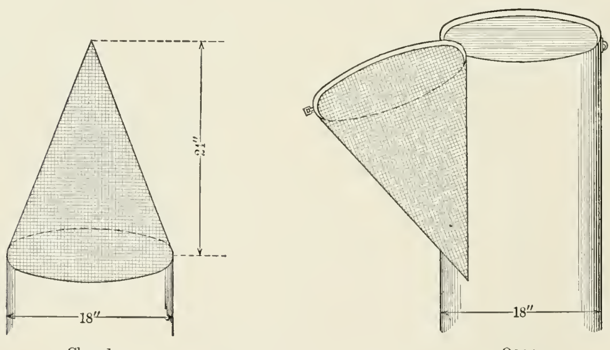

Fig. 4. — A Locomotive Spark Cap.

wire cone-shaped spark cap, 24 inches high and 18 inches wide at the base, where it is attached to a ring, which is hinged to another ring in the top of the stack. When in position the cone is fastened down on the stack by a hasp. When not in use the arrester may be dropped by the side of the stack. During the fall and winter the caps are removed and stored until the follow-

[1] Described in Forestry Quarterly, Vol. IV, No. 1, page 2.

ing spring. Engineers who have used them state that they do not interfere with the draft. The cost of manufacture in a railroad shop is about $3 each.

Boomerang Spark Arrester.[1] — This is used by many loggers on the Pacific Coast for coal-burning and wood-burning stationary engines. The essential parts of the arrester, Fig. 5, are a heavy $\frac{1}{4}$-inch mesh round screen (*A*), slightly flaring toward the top, on which is mounted a heavy sheet iron cone (*B*). The latter ends in a boomerang (*C*) to the open end of which a screen conveyor tube (*D*) is attached. The smoke passes out through the screen while the sparks travel straight up through the steel cone where they are diverted into the boomerang and led into a receptacle by the side of the engine. As the sparks do not come in contact with the screen it does not become clogged. The prices vary from $20 to $38 each according to the size.

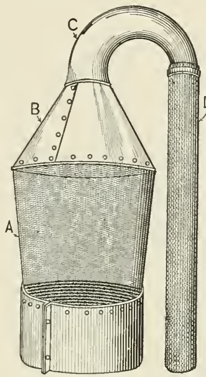

Fig. 5. — The Boomerang Spark Arrester.

Radley-Hunter Spark Arrester.[2] — This is an effective locomotive spark arrester which is used by many lumber companies, especially in the West.

The smoke and exhaust pass up through the main smoke chamber (*A*), Fig. 6, striking against a spiral cone (*B*) which gives it a whirling motion, and the large cinders are thrown outward by centrifugal force against the perforated screen plate (*C*). This plate has openings in it large enough to permit the passage of sparks into the spark chamber (*D*). Once through this perforated screen plate they are beyond the line of active draft, and by their weight fall into the cinder receptacle (*G*) from which they are removed through the cleaning out holes (*F*). The lighter sparks which are not thrown through the perforated

[1] Manufactured by the Washington Iron Works, Seattle, Washington.
[2] Manufactured by the Lima Locomotive and Machine Co., Lima, Ohio.

screen plate are carried by the draft against the fine netting (*E*). In firing up, the natural draft through (*A*) around (*B*) and under (*E*) is unobstructed by netting. This has two advantages: (1) the possibility of clogging is eliminated; (2) there is an easy, free draft when starting the fire. This stack acts as a centrifugal separator which prevents the emission of the larger and more dangerous sparks and only allows the escape of small, light sparks which are dead by the time they leave the stack.

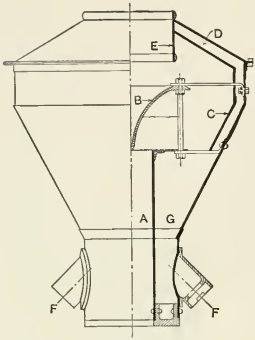

Fig. 6. — The Radley-Hunter Spark Arrester.

There are numerous other spark arresters but those described are the more common ones in use among lumbermen.

FUEL OIL

Sparks from locomotives have proved such a menace to forest property that in some states trunk line railroads which pass through forest regions are compelled to use fuel oil during the danger season because the many devices used to prevent the emission of live sparks from coal-burning and wood-burning engines have not proved entirely satisfactory. Fuel oil is not extensively used by loggers either for locomotives or for logging engines. For a short period after the discovery of the Texas oil fields many loggers in the cypress region of Louisiana fitted their logging engines with oil burners because fuel could be purchased cheap enough to reduce the expense of operation. A marked increase in the cost of fuel oil has led many to return to the use of coal or wood. Many loggers in the Inland Empire and the Pacific Northwest now use fuel oil successfully in locomotives, but so far no method for burning fuel oil in vertical boilers has been devised that is satisfactory for all conditions.

ELECTRIC DRIVE

Electric power for logging purposes will be used extensively in the future wherever it can be developed cheaply. A number of western firms are now experimenting with electrically-driven yarding engines and although still in the experimental stage they are giving good results.

PROTECTIVE ASSOCIATIONS

There are several associations[1] of private timberland owners organized in the Northeast, Lake States, Inland Empire and the Far West, whose object is the prevention and control of forest fires. These associations are composed of the largest timberland owners in a given region, whose problems of protection are similar. Some are local in character, others include an entire state, while one is interstate. During the fire season many of these associations maintain a patrol system with lookout stations, reserve tool stations, and approved devices for fire fighting. They usually support a paid secretary who is manager of the patrol force during the fire season and who also conducts educational campaigns in order to arouse public sentiment on the forest fire question. Hearty cooperation between state, national and private interests has been manifested from the first.

Associations are supported chiefly by an assessment of from $1\frac{1}{3}$ to 3 cents per acre. During 1911 the Western associations protected 954,000 acres at an average cost of $1\frac{1}{3}$ cents per acre.

No concerted efforts have been made by Southern operators, because the loss of mature standing timber is not considered great enough to warrant their interest.

[1] Among the more important associations are: The New Hampshire Timberland Owners Association, organized in December, 1910; the Northern Forest Protective Association, covering the states of Michigan and Wisconsin, organized in November, 1910; the Washington Forest Fire Association; the Oregon Forest Fire Association, organized in April, 1910; and the Western Forestry and Conservation Association, organized in January, 1909, representing private timberland owners in Washington, Idaho, Montana, Oregon and California. The object of the last association is to work for laws which will assist lumbermen in preserving standing timber from fire in public and private domains.

INSURANCE OF STANDING TIMBER

So far no standing timber in the United States has been insured.

Since timber bonds have been on the market there has been a demand on the part of investors for insurance protection but no active steps have been taken toward meeting it. Forest fire insurance will probably not be offered by reliable companies at a reasonable rate until better fire protection prevails and the practice of forestry is widespread. A company would have to carry a large amount of insurance scattered over a wide range of conditions in order that heavy losses in a particular region would not seriously embarrass it.

Even though some of the more prominent European companies insure timberlands they do not regard such risks as especially desirable. The Gladbach Fire Insurance Company of Munich established a forest fire insurance department in 1895. Its rates are regulated by the age, species, character of stand and general fire risk. On large, well-managed forest properties the premiums vary from 4 marks to a minimum of 0.45 mark per 1000 marks value, with an increase where the danger is great. The rate on forest plantations and protection forests is adjusted for each particular tract and the premiums often exceed 4 marks per thousand. Only forests that have a definite form of management and in which a sustained yield takes place are accepted as risks and then for minimum periods of ten years. The insurance value of the property is preferably determined by an expert appraiser, although the valuation of young timber may be made by the owner from tables of cost furnished by the company. In case of disagreement as to the basis of settlement between insurer and insured, provision is made for a board of referees whose judgment is final.

In case the property is over-insured, the company holds itself liable only for the actual value. The policy contains various clauses regarding the obligations of the insured to exercise due care in preventing fires, the use of steam engines in the forest, brush burning, etc.

An announcement[1] has been made recently of the organization of a mutual forest fire insurance company in Sweden, which marks a new departure in European forest fire insurance. A minimum premium is fixed and the highest risk taken is 75 per cent of the forest value. The latter may be based on the owner's estimate, or determined by an expert hired by the insurer at the expense of the insured. The damage is appraised by referees representing both the association and the insured, with final resort to the courts in case of disagreement.

The only fire insurance policy on timber on this continent was issued in 1910 by Lloyd's, London, to Price Brothers Company, Ltd., of Quebec, Canada, as additional protection for a bond issue of $5,000,000 which they wished to float. The basis on which the policy was issued was the division of the area insured into blocks of approximately 300 square miles, the boundaries of which were natural barriers such as rivers or mountain ranges. The average value of the property per square mile was determined by estimate, and the policy contains a clause that the insured must bear all the loss up to $75,000 in a given block. The underwriters' liability in a given block was limited to $250,000. The premium rate was 0.25 of one per cent of the total value of the property.

WIND DAMAGE

The zone of greatest damage from wind is in the yellow pine region of the South in the vicinity of the Gulf of Mexico. Many heavy storms have passed through various sections in this region destroying millions of feet of timber. In September, 1909, over one-half billion feet was blown down, some of which was manufactured, while large areas could not be logged in time to save the timber from insect attacks. These storms are especially destructive in timber weakened by boxing for the extraction of crude turpentine.

Extensive wind damage has been comparatively rare in the Northeast, although more than 1,500,000,000 feet of softwoods

[1] See Forestry Quarterly, Vol. X, No. 2, p. 304.

were blown down in Maine during a storm in November, 1883, less than 2 per cent of which was saved.[1]

Timber blown down in the fall is free from insect pests until the following April, after which the sapwood is soon rendered valueless on account of the holes made by insects and by fungi which enter these burrows and discolor the wood.

Light storms frequently occur over many parts of the southern forests and blow down individual trees. These can be saved provided the timber is not too far distant from a mill. If the amount of timber is sufficient to warrant it, small mills are established to manufacture the timber into lumber.

There is greater need for tornado insurance than for fire insurance on timber in the South, but the writer has no knowledge of any such policies.

The percentage of the total stand destroyed by storms in other forest regions of the United States is comparatively small.

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[1] See Report of the Forest Commissioner of the State of Maine, pp. 40–42, Augusta, 1902.

CHAPTER III

TIMBER BONDS

Bonds with standing timber as security were first placed on the market in 1902, as a result of unsatisfactory financial conditions in the lumber industry in the South, where lumbermen were often forced to borrow from local banks to meet current expenses, such as payroll and freight rates. These banks not only charged high rates, but often demanded payment when the lumberman was not in position to meet his obligations especially since his products were sold to parties who demanded from sixty to ninety days' time.

The rapid growth of the lumber industry required some new method of financing operations which would eliminate floating debts and short time loans, provide ample funds for financing the operation, permit lumbermen to carry a sufficient stock of lumber to meet market requirements, enable the discounting of bills with resulting economy, and concentrate the indebtedness. This need was met by the issuing of bonds which were first confined to the South, but are now common in the West, and a few issues have been floated in the eastern part of the United States.

Timber bonds require a higher margin of safety than those of most public utilities because the profits on lumber are subject to a greater fluctuation during industrial depressions and may become so small as to jeopardize the value of the bond. They have an advantage, however, over many industrial bonds in that they are secured by a natural resource fast being depleted and the ownership of which is rapidly being concentrated in comparatively few hands. This leads to greater stability of values, and timber bonds of the best class are rapidly coming into favor among conservative investors, especially those who are familiar with forest properties.

The chief security rests upon the stumpage. Conservative bond issues do not aggregate more than 40 or 50 per cent of the present value of the stumpage, based on an appraisal by competent timber estimators. In view of the constant increase in timber values and the awakening interest in fire protection this limit is ample for the protection of the bond holder.

Sawmill plants, railroads and logging equipment are often made a part of the security offered, but they should constitute only a small portion of the total, for while they are indispensable to the conversion of stumpage into a salable product, their value is chiefly dependent on the supply of stumpage back of them. Sawmill plants rapidly depreciate in value, are a bad fire risk, and on the exhaustion of the stumpage the owners can seldom realize more than 20 or 30 per cent of the cost. They should not be relied upon to any great extent as security even though heavily insured. Logging railroads are usually temporary in character, and the rights-of-way are often abandoned as soon as logging in a given section is completed; therefore, unless the road is to be continued under charter, the chief value is in the worth of the rails and equipment.

Timberland has not as yet been accepted as security in a bond issue, but when valuable for agricultural or other purposes it adds strength to the financial resources of the mortgagor.

Where the title to the land is in doubt, the timber standing on it should not be accepted as security. Timber rights that do not expire previous to the maturity of the bond issue are accepted as security at one-fourth their value by some underwriters.

Some of the more recent issues have been guaranteed by wealthy lumbermen, which forms a further basis of security although many desirable bonds are not so guaranteed.

Timber bonds as a rule yield 6 per cent with a premium varying from $101\frac{1}{2}$ to 110 when the bonds are retired before maturity.

The issues mature in from ten to thirty years, the first of the series coming due in from six months to two years after issuance, the remainder at semiannual or annual intervals. The retirement of all bonds is made optional and most mortgagors take advantage of this fact to pay off the issue as rapidly as possible.

Bonds are issued in denominations of $500 or $1,000 with the exception of a speculation series on the Pacific Coast which may be purchased in denominations of $100. The largest bond issue was that of the Long-Bell Lumber Company of Kansas City, Missouri, for $9,000,000, maturing in fourteen years at semi-annual periods. These draw 6 per cent and any or all may be paid at any interest period prior to maturity on sixty days' notice, at a premium of 1.5 per cent and accrued interest.

Sinking Fund. — The amount of the bond issue is based largely upon the standing timber owned by the mortgagor. It is essential, therefore, that the loan be reduced as the stumpage is cut. This is accomplished by depositing with a trustee a certain sum for each thousand feet cut or to be cut within a given period. These funds are then used by the trustee to meet interest charges and also to pay off bonds as they become due. Many bonds call for the payment of the deposit at intervals of thirty or sixty days; in some cases every six months, or at the end of the logging season, where, as in the North, logging is carried on only for a portion of the year. The safest bonds are those calling for payment in advance of cutting. The amount paid is often based on an estimate of the stand by "forties" as shown by the sworn report of the cruiser. Provision should also be made for the payment for timber destroyed or injured by fire, wind, insects, or other causes, on the same basis as for the timber that is logged. Numerous issues have not contained provisions of this latter character, but they cannot be regarded as a safe investment because fire and winds may wipe out a large part of the security, and unless some provision is made to offset this the sinking fund will not be sufficient to meet the bonds when due, or at least the bond purchaser will not have the protection to which he is entitled.

There is no uniformity as to the amount per thousand feet paid into the sinking fund. It ranges from $1.50 to $6 per thousand feet, the greater number of bonds calling for a payment ranging from $2.50 to $3.50 per thousand feet. As a rule lumbermen prefer to pay approximately the value of the stumpage into the sinking fund, because as the price of stumpage in-

creases and protection becomes more certain, the tendency will be to regard timber bond issues with greater favor and bond buyers will be satisfied with a lower rate of interest. Therefore, it will be more advantageous to the stumpage owners to pay off their indebtedness as soon as they can do so, and if necessary secure a later loan at a more favorable rate. Unless a company is well fortified financially, a heavy payment may impose a hardship on operators during periods of depression, and if the margin of profit is not sufficient to meet a high sinking fund rate the company may be forced to default on the bonds.

Floating a Bond Issue. — Timber bonds are now sold by a few brokerage firms in the East, and also some of the larger cities of the Pacific Coast but their chief market is in Chicago. They are handled by some brokers in connection with other bonds, but many of the best issues have been placed on the market by brokers who make a specialty of timber bonds. Although the majority have been sound there have been some unsafe issues floated, largely because the investigation prior to the acceptance of the bonds was superficial, and the brokers did not understand the nature of the securities they wished to sell.

A timberman who desires to float a bond issue on his property applies either to a bond house or banker to negotiate the loan.

One of the foremost timber bond brokerage houses in the country, which claims to have sold about sixty million dollars' worth of timber bonds without a default of principal or interest, gives the following as their mode of procedure previous to negotiating a loan.

"When a lumber company desires to make a bond issue on its timberlands and sawmill plant as security, we require of it a general statement showing the valuation of the property, the number of acres of timberland, varieties of timber, the estimated amount of lumber it will produce, and other information of a general nature, including the amount and purpose of the bond issue desired.

"If the security seems ample to make such bond issue safe and investigation into the credit and standing of the company is satisfactory, we agree to accept the bond issue if our own

independent preliminary investigation results in bearing out the statement furnished by the company that has made application for the bond issue.

"Every timberland bond issue handled by us must conform to the following high standard of security.

"(*a*) The company issuing the bonds must be well established in high credit; its officers and managers must be thoroughly experienced and in good standing among lumbermen.

"(*b*) The lands must be well located, contain timber of good quality, the amount thereof to be in every case determined by capable, well-known timber estimators, employed by us to cruise the timber which, in every case, must have a cash market value of at least 50 per cent in excess of the bond issue.

"(*c*) The titles to the lands must be carefully examined and approved by our own legal counsel.

"(*d*) The mortgage securing the bonds must contain strict provisions which operate to insure the regular deposit of an agreed amount per thousand feet for all timber cut sufficient to retire all of the bonds when about one-half of the timber is consumed; these deposits to be applied to the payment of the principal of the bonds as the several serials, semiannually or annually, become due. The mortgage makes provision for keeping careful check upon the cutting of timber and accounting for the same to the mortgage trustee."

If the statement of the company is satisfactory, a detailed examination is made, including a thorough estimate of the standing timber and other property; a study of the efficiency of the operation; cost of production and sales; inquiry into the shipping facilities, and all other factors that may influence the operation and profits of the business. This examination is made by men trained especially for the work because it requires a wider range of knowledge than is possessed by the average timber cruiser.

The expenses incident to a bond issue are borne by the party who desires to secure the loan. They include an audit of the books, a timber cruise, legal charges for examination of titles, drawing the deed of trust, drafting the text of the bond, charges

of the trustee, the cost of printing the mortgage, lithographing the bonds and other incidental expenses.

Some bond houses cruise the cut-over areas at occasional intervals in order to check up the original estimates and the actual manufacture of lumber; examine other portions of the timberland property which is security for the bonds in order to learn whether any timber cut has not been reported, or has been killed by fire, wind or insects; and also investigate the general management of the property for efficiency. By this means a close check is kept on the conduct of the business and the rights of the bond holders can then be fully protected.

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PART II

PREPARING LOGS FOR TRANSPORT

CHAPTER IV

FOREST LABOR

The successful conduct of forest operations depends in a large measure on the character, supply and efficiency of labor, factors which are influenced by the economic conditions of the country. In prosperous times work is abundant and capable men are not attracted by the average wage paid for forest work. This means a restless woods force, a portion of which constantly shifts from camp to camp. Business depression is quickly felt in the lumber industry because in hard times railroad companies and other large consumers of forest products reduce their purchases of lumber, crossties and other material. The dull market prompts the lumberman to cut down expenses and one of the first steps taken is to reduce the labor charge since this is one of the chief items in the cost of lumber production.

The agricultural interests of different regions may also have a decided influence on labor supply during certain seasons. This is illustrated in the cypress region of Louisiana, where sugar production is an important industry and where creoles and negroes prefer to work in the fields and sugar mills during the cane-harvesting season.

LENGTH OF EMPLOYMENT

The length of time forest laborers are required each year is governed by the character of the operation. In the northeastern part of the United States, in some parts of the Lake States and in the Inland Empire there is a demand for the maximum number of laborers only from eight to nine months of the year; in the southern pine, cypress and Pacific Coast forests, where railroading replaces sled haul and water transport, loggers operate the year round.

CHARACTER

During the early years of the industry the woods force in the North and East was recruited from the native agricultural element, but in recent years it has been replaced by French Canadians, Finns, Swedes, Danes, Poles and inhabitants of southern Europe. French Canadians come over the border during the fall and winter months to secure a "stake." Many Swedes and Norwegians, who are among the best woods-workers from Europe, are employed in the Lake States and on the Pacific Coast where wages are high. Finns and Poles work chiefly in the Lake States. The American-born employees are now found in the more responsible positions.

The labor in the Appalachians consists largely of natives, some of whom combine agriculture with logging while others follow logging as their sole occupation.

Whites and negroes comprise the chief forest labor of the South, although creoles and Mexicans are common in the Louisiana cypress swamps, and many Mexicans are employed in Texas, especially around the mills and on railroad construction work. The whites are often agriculturists who work at logging only for a portion of the year, while the negroes, except in the sugar country, follow the industry the year round with frequent shifts from one camp to another. Owing chiefly to the climate the laborers are, on the whole, less energetic than those in northern regions. The color line is drawn on logging operations and mixed crews are not the rule. Creoles and Mexicans work with colored laborers, although Mexicans are inclined to be clannish.

METHODS OF EMPLOYMENT AND OF PAYMENT

The chief methods of employing labor are (1) by the day or month; (2) by contract.

The first is desirable where labor is efficient. Even where the bulk of the work is done by contract, a small force should be maintained to prevent the arbitrary dictation of prices by contractors.

The basis of employment in the Northeast, Lake States,

Inland Empire and on the Pacific Coast is generally by the day or month, with or without a charge for board. Day labor predominates on the Pacific Coast, while in the other sections a monthly wage is more common. When employed on the latter basis, workmen may or may not be charged with lost time due to bad weather or to sickness.

Contract labor is preferable where labor is inefficient and liability laws are unfavorable to the employer. This method is common in the southern yellow pine, cypress and the Appalachian regions. The system is extended in some regions to cover the entire field of mill-stocking, although it is usually applied to felling and log-making, skidding, hauling and railroad grade construction. The last is almost invariably a single contract, but the others may be handled together. For instance, one contractor may agree to deliver the logs along the railroad.

The common basis of payment for contract logging work is by the thousand feet, log scale. When this method is not used, felling and log-making are paid for by the log, tree, number of saw-cuts made or by the "task." The latter is really on a day wage basis, because the workmen receive a stated sum per day, provided they cut a given number of logs, or a certain number of feet, log scale. The task is common in the Carolinas and in some portions of Arkansas.

Some lumbermen furnish the contractors with tools and supplies. This may cover only felling and log-making, or it may be extended to include the skidding and hauling equipment, either power or animal, and the railroad or other means used in transporting the logs to the mill. Such an arrangement materially affects the contract price.

Small contracts are usually verbal but large ones are generally in writing. About 10 per cent of the contract price is usually withheld until the work is satisfactorily completed.

Many lumber companies operate commissaries or general stores in connection with their logging and milling work. Since it is to their advantage to have the trade of their employees, cash is paid only on specified pay days. Meanwhile, employees may obtain metal trading checks or coupon books to the value of their

credit which are accepted at face value at the company store. This tends to keep the trade at home, especially if the company discourages the redemption of their checks or coupons when presented by others than employees.

Weekly, semi-monthly, or monthly pay days are the rule in the South. A practice also exists among some operators of deferring payment for two weeks or a month in order to hold the men.

In other regions loggers do not have regular pay days but the woodsmen are given credit at the camp store for such supplies as they need. Final settlement is made by check or by order on the head office or some store or bank when the man leaves the employ of the logger. When labor is scarce special inducements such as payment on demand instead of at some fixed date are sometimes offered to secure workmen.

FACTORS WHICH INFLUENCE WAGES

The wage paid for forest work depends largely on the following factors:

(1) The amount of labor available.

(2) The degree of skill required.

(3) The condition under which labor is performed. Laborers prefer to work near settlements and may demand higher wages on remote operations, and where low stumps, brush disposal and other restrictions demand the exercise of greater care and effort than usual.

(4) The perquisites offered. Labor can be secured more readily and at a lower wage where hospital, accident insurance, school, church and like benefits are afforded.

A list of the wages paid in several forest regions is given on pages 531 to 535, inclusive, in the Appendix.

UNIONS

Forest employees in the Northeast and Lake States have no regular form of labor organization.

In the Inland Empire and on the Pacific Coast unions exist which have state organizations supporting a staff of organizers

and inspectors. Boycotts and strikes have in some instances been conducted by these organizations but in general the industry has been free from disturbances due to organized labor. An important feature of some of these unions is a hospital benefit.

During the years 1911–1912 sawmill employees and woodsworkers in Louisiana and Texas attempted to organize a union known as the "Brotherhood of Timber Workers," in affiliation with the "Industrial Workers of the World." The movement promoted by inflammatory leaders grew rapidly and during the year 1911 caused several of the largest mills in these states to close for a time. The organization has not been a success.

ORGANIZATION

The usual division of responsibility in logging operations is shown on pages 52 and 53. The first is that of a large operation in the yellow pine region of the South; the second, the form common in the North.

WORKMEN'S COMPENSATION ACTS

For many years the responsibility of compensating laborers injured in the performance of their work was regulated by Employers' Liability Laws. These held the employer liable for accidents which occurred by reason of his failure to conform to the laws. Lawsuits were frequent and usually proved expensive to all concerned, often resulting on the one hand in a denial by the courts of compensation to parties to whom it was due, and on the other in granting heavy damages to those who were not entitled to them.

The employers protected their interest through liability insurance companies but a great waste of money resulted since only from 29 to 50 per cent of the premiums paid reached the injured employees or their dependents and fully 40 per cent of this was expended by the injured party for attorneys' fees.

Compensation through liability laws has tended to create an antagonistic feeling between employer and employee and for

ORGANIZATION OF A SOUTHERN RAILROAD OPERATION

General Manager.	Location engineer (main line railroad).	Grading contractors.	Laborers.
	Woods foreman.	Team boss.	Teamsters. Swampers.
		Felling contractor.	Woods sawyers.
		Camp blacksmith.	
		Barn man.	
	Train master.	Grading boss (spurs).	Laborers.
		Loader foreman and engineer.	Loader crew.
		Steel crew foreman.	Steel crew.
		Train conductors.	Train crews.
		Section boss.	Section crews.
		Shop foreman (mill).	Shop crew.
	Assistant manager.	Sawmill foreman.	Sawmill crew.
		Yard foreman.	Graders (green lumber). Sorters. Teamsters. Pilers.
		Dry kiln and dry shed foreman.	Kiln truck loaders and unloaders. Graders (dry lumber). Assorters.
		Supply clerk.	
		Head carpenter.	Carpenter crew.
		Shipping clerk.	Truckers to planer. Loaders.
		Planing mill foreman.	Planing mill crew.
	Land agent.	Cruisers.	
	Log scaler.		
	Chief clerk.	Office force. Mill watchmen.	
	Storekeepers.	Assistant storekeepers. Clerks.	

ORGANIZATION IN THE NORTHERN WOODS

General Manager.	Woods foreman.	Scaler and clerk.	
		Saw boss.	Sawyers.
		Saw filers.	
		Road foreman.	
		Toters.	
		Cook.	Flunkies.
		Skidding foreman.	Teamsters.
			Swampers.
			Skidwaymen.
			Barn man.
		Road repair crew.	
		Landing boss.	Landing crew.
	Drive foreman.	Log drivers (small streams).	

many years this method of settlement has been regarded as unsatisfactory.

In recent years several states[1] have abolished the liability laws and have passed Workmen's Compensation Acts which provide, without trial by court or jury, for the payment of specified sums for injuries received. The injured workman secures a definite compensation without any legal expense and without regard to the cause of the accident, provided it was not self-inflicted. The employer must waive all rights to the common law defences of "contributory negligence," "assumption of risk" and the "fellow servant rule," which were prominent features in litigation under the liability laws.

One of the most satisfactory Workmen's Compensation Acts, from the standpoint of the lumber operator, is now in force in the state of Washington, having gone into effect in October, 1911. This law provides for an Industrial Insurance Commission to administer the law and for the payment, by the State, of all expenses of administration of the Act, placing the burden of compensation on the employer.

Among the features of this law are the following:

(1) When engaged in hazardous occupations the provisions of the Act are obligatory on both the employer and employee,

[1] Among these are California, Washington, Wisconsin. New Jersey, Illinois, New Hampshire and Kansas.

and it is optional with others. Those who come under the provisions of the law waive all rights to the common law defences, and the employee must accept the awards of the Commission, in lieu of his right to sue at common law.

(2) Any employer, workman or beneficiary has the right of appeal to the Superior Court in the County of his residence, when the award is not satisfactory. If the Court deems the award unjust, the Commission must pay the plaintiff's costs and attorneys' fees out of the administration fund.

(3) The awards are made from a fund contributed by the employers, who pay a certain percentage[1] of their payroll to the Commission.

(4) The various industries and parts of industries are grouped separately according to the degree of hazard, and each class has a fund of its own from which awards are made for such accidents as arise to its employees. In case of the depletion of the fund, provisions are made for special assessments to cover the deficit. Although the fund is not intended to be cumulative, there is no provision for a reduction of the assessment fixed by law.

(5) It is unlawful for the employer to deduct from the wages of the employee any portion of the premium paid into the accident fund.

(6) All forms of injury are classified and a standard schedule of awards is fixed for each.

(7) In case of the death of an employee a pension is granted to the widow during her unmarried life, including an allowance for each child under sixteen years of age, up to a maximum of three children. Orphans receive an allowance twice that granted to children who have a parent living. Provision is also made for dependents when the deceased has no immediate relatives.

(8) Pensions are met by setting aside a specified sum, based on mortality tables, which is deposited with the State Treasurer, and from which the payments are made when due.

(9) If a workman deliberately injures himself, or causes his own death, no award can be made from the accident fund. On

[1] The rates for the lumber industry are as follows: logging railroads 5 per cent; logging operations, sawmills and lumber yards, 2.5 per cent.

the other hand, if the employer brings about such injury or death through negligence, the widow, children or dependents come within the provisions of the Act, and further have cause for action against the employer for any damages in excess of those awarded by the Commission.

(10) Provisions are made for penalizing an employer who fails to observe the safeguards required by law. He must not only pay the regular percentage on his payroll but, in addition, 50 per cent of the award granted to the injured party. If the workman removes, or allows to be removed, any safeguard and he is injured thereby, the award is reduced 10 per cent.

(11) Employers are required to report all accidents to the Commission, and their books must be open to inspection by the traveling auditors of the Commission.

(12) Application for relief under this Act must be made within one year from the date of the accident.

The adoption of this Act has led to the abandonment of liability insurance by lumbermen in Washington, and many operators believe that ultimately it will prove to be a cheaper form of settlement for accidents than has previously been available, as well as promoting a better feeling between employer and employee.

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CHAPTER V

CAMPS

In early times camps were crude structures having few, if any, conveniences and the men were given very plain fare but a logger can no longer crowd a large number of men into a small building, and feed them on plain, poorly-cooked food, for the increase in the demand for labor in the woods and the constantly growing scarcity of competent help have forced loggers to make their camps more comfortable and to furnish a bill of fare that compares favorably with many hotels.

CAMP LOCATION

The requirements for a camp site for snow logging may be summarized as follows:

(1) A central location with reference to a large tract. It is not considered profitable to walk men more than $1\frac{1}{2}$ miles from camp to work, or from one watershed to another, because they consume too much time and energy. It is cheaper to construct new camps if there is a large amount of timber, or a secondary one if the quantity is small. The camp should be located so that the main haul or two-sled road will run through the camp lot on its way to the landing. Teamsters then lose no time in getting to work in the morning, returning to feed animals, and getting them to stable at night after a hard day's work. During the hauling season time is an important factor, and where long hours are observed every precaution should be taken to husband the strength of animals and men.

(2) A level, well-drained camp site from one to two acres in extent which is free from large boulders that would be a hindrance to the location of buildings.

(3) A stream of pure running water near at hand for drinking, cooking, laundry purposes and stock watering, and so located that it will not be contaminated by the camp.

(4) Accessibility to the source of supplies is an important factor, although secondary to proper location with reference to the timber and main haul.

The requirements for a camp site for a railroad operation may be summarized as follows:

(1) A well-drained site, with no swamps or other mosquito-breeding spots in the vicinity, because railroad camps are operated during the warm season when there is the greatest danger from malaria.

(2) Location with reference to a natural supply of pure water is secondary to good drainage since drinking water is either hauled to the camp in tank cars or can be obtained by driving wells at the camp site. It is desirable, however, to have a running stream in the vicinity from which water for the stock and for laundry purposes may be secured.

(3) Accessibility to the operation is essential unless the men can be transported to and from their labor by train.

(4) A sufficient area of level ground to permit the construction of the spur tracks required for moving the houses and also set-out switches for log cars.

Floating camps are placed in bayous and canals in proximity to the operation. Pure drinking water cannot be secured from these streams and provision must be made for a boiled or distilled supply.

TYPES OF CAMPS

Log Camps.—Typical buildings are usually one story high and are constructed crib-fashion of logs, preferably of conifers with the slightest taper obtainable. These are notched at the corners to hold them together and to reduce the chink space which is filled with moss and clay, or mortar. The floors in the living rooms are made of hewn timber or rough lumber, and the roofs are covered with "shakes" or prepared roofing. The doors are made from rough boards, and a few windows furnish light and aid in ventilation. Occasionally a framework on which logs are fastened upright is substituted for the crib-work.

Log camps in the North generally comprise the following buildings:

(1) An office and store, sometimes called a "van," which is the headquarters and the sleeping place of the foreman, camp clerk and log scaler. The equipment of the room consists of single bunks for the men, a few shelves on which goods are displayed, and a rough counter over which they are sold, two or three homemade chairs, and a box stove. The store carries necessaries required by the woodsmen, such as shoes, clothing, tobacco and a few drugs. Occasionally the office is in one of the main buildings.

(2) A cook shanty housing the kitchen and dining department. The former is usually placed in one end of the building, and the remaining space is devoted to long board dining tables running lengthwise or crosswise of the building. Benches are provided for seats. A small sleeping room is partitioned off for the cook.

(3) A bunk house providing lounging and sleeping quarters for the men. Double bunks two stories high are built along the side wall and often across the ends of the building. Each bunk accommodates two men. Straw or hay is supplied in lieu of mattresses. Blankets may or may not be supplied by the camp.

The furniture consists of long wooden benches, called "deacon seats," ranged alongside of the bunks. A large sink for washing, one or two heating stoves, and a grindstone are also part of the equipment. Wires for drying clothing are suspended over the stove.

Ventilation is often secured by placing a barrel in a hole in the roof and fitting it with a hinged head that may be opened and closed; if this is not used, some other crude arrangement is adopted.

Cook shanties and bunk houses are generally separate buildings, although in the Northeast they are often only from 6 to 10 feet apart, and the gap is covered with a roof, boarded up in the rear and used as a storage place, called a "dingle."

Two-storied camps, having the kitchen and dining-room on the lower floor and the sleeping quarters on the second floor,

are sometimes used in the Adirondack mountains, although the general practice is to use one-storied buildings.

(4) Stables or hovels — rough buildings with a good roof and fairly tight sides — are constructed to afford proper protection to animals. They are equipped with stalls, feed boxes, harness racks and grain bins. Each animal is usually allowed a stall space of 5 by 10 feet. When a large number are kept in one camp, the stalls are arranged on opposite sides of the building

Fig. 7. — Typical Logging Camp of the Northeast, showing the cook shanty in the foreground, the bunk house, the blacksmith shop, and the stable at the extreme right. Maine.

with an alleyway in the middle in which grain and hay are stored. A 6-foot runway is left behind the animals to facilitate cleaning the barn and to afford a passage for the animals to and from their stalls. The barn equipment, including harness, costs about $55 per team.

(5) A storehouse, where large quantities of supplies are kept. This may be a detached building or a room in the cook shanty set aside for this purpose.

(6) A storage or root cellar which is an underground place where vegetables are kept. It must be frost-proof and yet cool enough to prevent the produce from spoiling.

(7) A blacksmith shop where horses are shod, sleds and other equipment made and repaired, and similar work done. If a variety of work is performed there must be a fairly complete set of iron-working and wood-working tools.

Photograph by H. DeForest.

Fig. 8.—A Two-storied Logging Camp. The dining-room, lounging room, and office are on the ground floor, and the sleeping quarters are on the second floor. Northern New York.

The following list comprises the chief tools required in a first-class camp shop:

1 forge, complete, including bellows
1 anvil
3 augers, $1\frac{1}{4}$-, 2- and 3-inch
1 thread cutter and an assortment of dies
4 hammers
1 vise
1 broadax
2 rasps
1 coal shovel
12 tongs, assorted
1 brace and an assortment of bits
1 drill machine and an assortment of drills
1 bolt clipper
1 striking hammer
2 monkey wrenches
2 two-inch iron squares
1 set of horse-shoeing tools
1 iron heating stove

A general assortment of cold chisels, drawing knives, pinchers and an assortment of files.

(8) Sled storehouses to shelter sleds and other equipment during the summer months.

An average crew for the northern woods is about sixty men, and in addition from twenty-five to thirty-five horses. A camp to accommodate a crew of sixty men and thirty horses would be composed of buildings of the following approximate sizes:

Office and store	16 by 20 feet
Cook shanty	35 by 37 feet
Bunk house	35 by 37 feet
Stables (2)	40 by 40 feet
Storehouse	16 by 16 feet
Blacksmith shop	27 by 27 feet
Storage cellar	8 by 12 feet
Sled storehouse	10 by 15 feet

A camp of this size was built in Maine with a total expenditure of 300 days' labor and twenty days' teamhire at a cost of approximately $600. Three and one-half million feet of timber were logged annually from this camp for three years, so that the cost of camp construction was about 6 cents per thousand feet log scale. On some operations this charge may run as high as 10 cents per thousand feet.

In some parts of the North especially where logging railroads are used, log buildings have been replaced by board camps covered with tar paper. Buildings of this character are torn down when a camp site is abandoned and the lumber is used for buildings on a new site.

Portable-house Camps. — The buildings in these camps are used indefinitely and are moved from place to place as logging progresses being placed on skids along either side of the main line or of a spur of the logging railroad. Two or three of them grouped together may form a dwelling for a family, or singly they may be fitted up as bunk houses to shelter two or more men. Large camps in the South may consist of 200 or more houses and shelter from 200 to 300 persons, of whom only from 30 to 50 per cent may be men in the employ of the logging company.

Camps of this character constitute small villages with a school and church for the benefit of the loggers and their families. Other buildings include quarters for the superintendent, sometimes a boarding-house for single men, barns for the stock, a machine shop, storage houses, coal supply bins for the locomotives and a commissary or store. The latter is an important feature in isolated camps for not only the families in camp but also many of the local inhabitants secure their supplies from this source. Stores of this character often carry a large stock of goods and sell monthly several thousand dollars' worth of merchandise, groceries and feed.

Fig. 9. — A Portable-house Logging Camp. The large building in the rear is the commissary or general store. Arkansas.

When families do not live in camps the number of buildings is limited and may include, besides the bunk houses, an office and a cook shanty. The latter because of its large size frequently is not portable. A small "van" is maintained from which the men can secure such necessities as they require. Camps of this character are found in the Northwest.

Portable houses must be of a size that can be loaded readily and transported on log cars. Strength in construction is an important factor, because of the frequent handling to which they are subjected.

The buildings vary in size and in mode of construction. In the South they are 12 by 14 feet or 10 by 20 feet, with a door at each end and a window in each side. The framework on which the floor joists rest is made of heavy timbers, and the side bracing, floor joists and rafters of 2- by 4-inch material. The siding may be 4-inch dressed and matched material, and the interiors of the better houses are ceiled with $\frac{3}{8}$-inch ceiling. A cheap grade of flooring is used. The roof is covered with sheet iron or some patent roofing material.

A house of this character 10 by 20 feet in size requires approximately 2200 feet of lumber, 230 square feet of roofing, 4 window sashes, 4 pairs of hinges, 2 doors and 2 door knobs. It can be built at a cost of from $45 to $60 each, including the value of material and labor, and if kept in good repair and painted at intervals will last for many years.

Portable houses are loaded on log cars either by animals or log loaders.

In loading a house with the aid of animals, the log cars are "spotted" on the railroad track opposite the house to be loaded and skids are placed from the house to the car. One end of a cable is attached to the house, the other end being passed over the car through a block and fall fastened to a tree or stump on the opposite side of the track. A team is attached to the free end of the cable and the house is dragged slowly up the skids and on to the car bunks.

A house can be handled most expeditiously with loaders, in which case there must be a heavy 6-inch by 12-inch timber running lengthwise or crosswise under the center of the building. An iron rod, $1\frac{1}{2}$ inches in diameter, having a large eye at one end and a screw thread at the other, is run through the center of the house from the peak of the roof down through the heavy floor beam and made fast with a nut. An empty log car and the log loader having been placed on the track opposite the house, the loader cable is fastened to the eye of the rod, and the whole structure is raised clear of the foundation, then swung around in position and gently lowered on to the car. It is unloaded by a reversal of the process. In some cases the rods are fixed per-

manently to two corners of the house, diagonally opposite, and a bridle on the loading cable is fastened to them when the house is to be moved. The movement of the house does not necessitate the removal of the household effects.

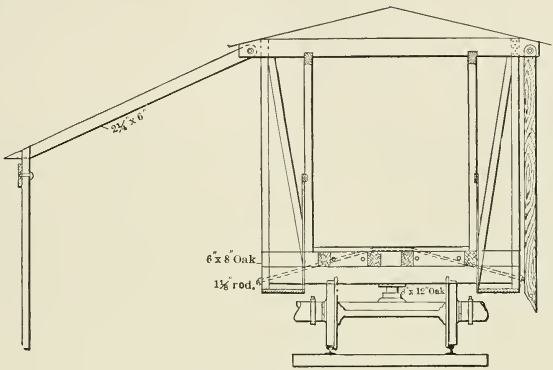
Barns for animals at portable logging camps may be either semi-permanent board structures, tents or specially constructed cars.

Board barns are advantageous in a region where the winter weather is severe since they can be made tight and afford ample shelter and comfort for the animals. They are built of cheap lumber with a board roof battened or covered with prepared roofing. Such structures are expensive when camp is moved frequently, because some lumber is destroyed each time the building is torn down, and the cost of erection is considerable. A barn of this character for the accommodation of from thirty-five to forty horses costs from $150 to $175.

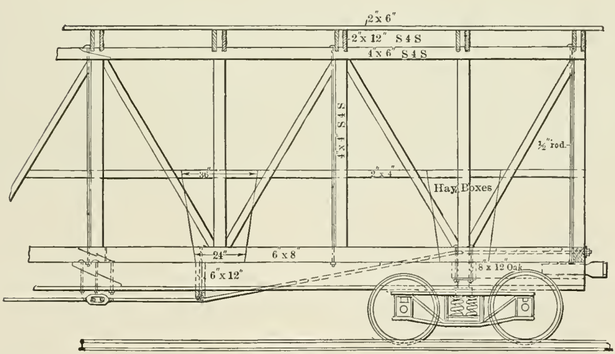
A form of tent barn 32 feet wide with 14-foot center poles and 7-foot side poles is recommended by some loggers for temporary camps. Double stalls are made 10 by 10 feet with 6-foot alleys at the rear. A barn of this character made from 12-ounce duck can be built for approximately $1.25 per linear foot of barn length.

Car barns are employed in some parts of the South and are considered very desirable by those who use them. A type of car barn used in Arkansas consists of a flat car 10½ feet by 40 feet in size, with standard freight trucks on which is built a superstructure 9 feet from the floor to the eaves, with a gradually sloping peaked roof covered with tar paper. A passageway 6½ feet wide runs through the center of the car which provides a place for the storage of hay and grain, and on each side of it feed and hay boxes are arranged. A drop roof, supported on 3-inch by 6-inch by 8-foot scantling, covers stall space 10 feet wide beyond which is an extension roof covering an alley. Four double stalls are arranged on each side of the car separated by board partitions wired to supports on the car and under the outer edge of the drop roof. The stable floor is filled in with earth to give drainage. No protection other than the short

extension roof is provided at the rear. The car is left on a temporary track and in one hour can be dismantled ready to move.



End View.



Side View.

FIG. 10. — An End and Side View of the Frame of a Car Barn.

A car of this character is serviceable where frequent changes of site are necessary. It is not suitable for a region in which the weather is severe during the winter months, although with

a little additional labor it would be possible to enclose it on the sides and ends. A car barn can be built for $400.

Corrals for idle animals are enclosed with panels five boards high and 16 feet long which are wired to posts set at proper intervals. The only labor required in moving to a new site is to cut the wire and load the panels on flat cars.

Car Camps. — Logging camps sometimes consist of a number of box cars fitted up for sleeping quarters, kitchen and dining-room, and office and commissary. They are moved from site to site as the work progresses and placed on a siding at each camp. The entire camp can be moved in a very short time, the men are always near their work, and it is claimed that car camps are more sanitary than frame ones because of their height above ground. Because of the increased investment these camps are not desirable where families must be housed.

In an Oregon camp the units are built on 34-foot flat cars and each consists of a superstructure 46 feet long, 14 feet wide and $8\frac{1}{2}$ feet high from floor to eaves. Ten cars provide accommodations for eighty men, five cars being used for bunk houses, and one each for kitchen, store room, dining hall, headquarters and commissary, and power and baths.

Each bunk car accommodates sixteen men and is fitted up with two-storied single bunks provided with springs and mattresses. The cars are steam-heated, electric-lighted and afford comfortable quarters for the men.

A unique departure is the power and bath car which is fitted up with a tub and four shower baths. These are available for the use of the men under suitable regulations. A power plant placed in this car furnishes light for the camp and a boiler furnishes steam heat for the buildings.

The office, commissary, and foreman's and storekeeper's quarters are placed in a single car, while a storage car holds supplies for the commissary and package goods for the kitchen.

Running water is provided for the camp whenever a gravity supply is available.

Floating Camps. — The camps used in the cypress region on pullboat operations are built on scows, and are usually two-

storied buildings in which the entire camp is fed and housed. A portion or all of the lower floor may be devoted to the kitchen, dining-room and foreman's quarters, while the upper floor is used to house the men and is generally divided into two sections to accommodate white and colored laborers.

A store building is moored so close to the main camp that the two can be connected by a gangplank.

FIG. 11. — A Floating Camp on a Cypress Operation. The dining-room and office are on the ground floor and the sleeping quarters are in the second story. The building on the left is the commissary. Louisiana.

Floating camps are tied up along the banks of bayous or of canals near the logging operation, and the men go to and from work in dug-out canoes called "pirogues" which are propelled with paddles.

BOARDING DEPARTMENT

A well-conducted boarding department is an essential in every successful camp where the logger must furnish subsistence to his workmen.

The more progressive loggers secure the best cooks obtainable to take charge of their boarding department, since the season's success usually depends on a constant supply of labor which cannot be retained unless good wholesome food is provided.

The kitchen force in a camp is in charge of a head cook, who controls the conduct of the kitchen and dining-room. An efficient man whom the company desires to retain is furnished any supplies he requests. A competent cook can prepare food for from 80 to 100 men, but for a greater number there should be an assistant. The cook has helpers called flunkies or cookees, who wait on table, peel potatoes, wash dishes and perform any odd jobs around the kitchen. One flunky to every twenty-five men is the general rule.

In addition every camp has a chore boy who cleans up the men's quarters, cuts firewood, builds fires and carries water for the men's camp, and sometimes cleans the stables.

Since it is customary to feed the entire crew at one time a camp requires a large amount of dining-room ware. Kitchen utensils may be of iron, tin or granite ware. Dining plates, cups and serving vessels are preferably of heavy granite ware, although some companies use heavy china plates. The cutlery is of steel with plain wooden handles.

The following list shows the equipment used in a northern camp where sixty men were fed:

1 six-hole cooking range	5 ten-quart pans	3 frying pans
4 bean pots	24 pepper and salt shakers	7 iron kettles
13 bread pans	74 spoons	1 porcelain kettle
4 butcher knives	3 sieves	2 meat grinders
1 chopping bowl	3 wash boilers	1 nutmeg grater
4 "dutch" ovens	9 lunch buckets	12 three-quart pans
80 half-pint cups	2 bake pans	10 two-quart pans
74 forks	4 beef boilers	18 pails
74 knives	7 baking pans	86 plates
24 ladles	7 coffee boilers	2 skimmers
10 molasses jugs	1 chopping knife	16 wash basins
10 mixing spoons	3 long-handled dippers	1 washboard
2 mixing pans		

The total value of the above camp equipment is from $200 to $225.

Rations. — The quantities of different foodstuffs that enter into two rations are as follows:

Article.	Unit.	100 rations.	
		(1)	(2)
Fresh meat	Pounds	100	89
Cured meat	Pounds	50	36
Lard	Pounds	15	18
Flour	Pounds	80	130
Corn meal	Pounds	15	8.2
Baking powder	Pounds	5	1.85
Sugar	Pounds	40	34
Coffee	Pounds	12	2
Tea, chocolate or cocoa	Pounds	2	2.8
Butter	Pounds	10	1.3
Oleomargarine	Pounds	...	1.6
Dried fruits	Pounds	20	13.7
Rice or beans	Pounds	20	35
Potatoes or other fresh vegetables	Pounds	100	162
Salt	Pounds	4	6.5
Peas	Pounds	...	4.25
Molasses	Gallons	1	0.56
Pickles	Quarts	3	......
Vinegar	Quarts	1	0.20
Milk, condensed	Cans	10	......
Canned vegetables or fruit	Cans	30	......
Spices	Ounces	4	0.60
Flavoring extracts	Ounces	4	......
Pepper or mustard	Ounces	8	......

(1) U. S. Geological Survey. (2) Maine logging camp.

The cost of feeding men in logging camps usually ranges from 45 to 65 cents per day.

Commissary supplies and animal feed are usually hauled into northern camps during the late fall and early winter on tote sleds. Where good roads are available, supplies are occasionally wagoned in during the summer. A two-horse team will haul about 1500 pounds of supplies daily for a distance of twenty miles on a sled, while a team of four horses will seldom haul more than 1000 pounds on a wagon. The toting charge ranges from 15 to 60 cents per 100 pounds. Supplies for railroad camps are brought in as needed.

CAMP HYGIENE

Many camps have no system of medical supervision and are far removed from hospitals or other facilities of this character; therefore, it is essential that the logger take every possible precaution to prevent disease on account of the danger of epidemics which may depopulate the camp either through sickness or the general exodus of workmen fearful of a disease. The greatest care must be exercised during the warm months when bowel troubles are prevalent, a frequent cause of which is poorly cooked or tainted food. Such diseases may largely be guarded against by supplying pure drinking water, by burning or burying all kitchen and stable refuse, and by providing tight latrines, so that flies cannot infect the food supply. It is imperative that all meat and other supplies be kept in screened enclosures, and if flies are abundant the kitchen and dining-room also should be screened. Such precautions are not expensive and often will avert serious sickness in camp.

The sleeping quarters should be well lighted and ventilated, and where many men are quartered in one building each workman should have 100 cubic feet of air space and 12 square feet of floor space. Where a large number of men are housed in one building it should be disinfected at least once a week. Personal cleanliness should be enforced, but this can only be done when suitable bathing quarters and laundry equipment are provided. Underclothing should be washed each week, since by doing so the men are kept in better health and the danger of wound infection from cuts is greatly lessened. A practice exists in some regions of hiring a man to do laundry work, charging each laborer a stated price. This is considered a better method than requiring the men to wash their own clothing because of the difficulty of enforcing this rule, and also because Sunday, which is the only available day for washing, is needed by the men for relaxation and rest.

MEDICAL ATTENTION

Lumber companies in some sections, particularly the South, where logging camps are located near the manufacturing plant,

maintain medical staffs and hospitals to care for their employees. This is especially the case where the town in which the plant is situated is controlled by the lumber company. Employees are charged a certain sum per month for medical attention, averaging $1.25 for married men and 75 cents for single men. The hospital fees are small and cover only the cost of board. The doctors visit the camp at stated intervals and are subject to call at any time for the treatment of persons critically ill or seriously injured.

The medical staff may be employed by the company on a salary basis, or the doctors may be allowed all fees, except 10 per cent retained by the company for collection.

In some of the western states the loggers' unions make arrangements with hospitals for the care of sick or injured members, each of whom by the payment of a monthly fee of 50 or 75 cents becomes eligible for a ticket which insures him medical attention. The hospitals which are located in a number of the larger cities in the Inland Empire and on the Pacific Coast are not controlled by the unions. The medical benefits of the unions do not extend to the camps.

CHAPTER VI

WOODWORKERS' TOOLS AND EQUIPMENT

AXES

An ax head consists of two parts: namely, the bit or cutting edge and the head or poll. The latter has an eye into which is fitted the helve or handle. There are several types of axes, chief among which are the felling ax, the broadax and the turpentine ax.

Felling Ax.—This is used for felling, log-making, swamping and other chopping work. The head is made in a variety of patterns and of several weights. It tapers from the poll to the bit and has either smooth, slightly concave or beveled sides. The eye is oval-shaped and has a larger diameter on the side opposite the handle in order that a wedge may be inserted in the handle head. The head may have one or two cutting edges. The former is known as a single-bitted and the latter as a double-bitted ax. A single-bit is in common use where a light ax is required, where a single cutting blade is needed, or where the ax is to be used for striking. A double-bitted ax is serviceable where a woodsman has need of a sharp cutting edge, and at times must cut dry knots and other material that quickly dull the tool. It is a favorite with swampers and some sawyers prefer it for driving wedges.

Bits are made of steel and are either straight or curved. They must be properly tempered for if too soft the edge will turn and if too hard it will break.

The weight of the head depends on the character of work that is to be performed and the personal ideas of the laborer. For felling in ordinary timber a head weighing from $3\frac{1}{4}$ to 4 pounds is generally used. This is somewhat lighter than those used by swampers and others who cut limbs and brush, snipe logs and perform similar work.

The handles for single-bitted axes are either curved or straight, the choice being largely one of individual preference. Handles are preferably of second-growth hickory, but if made by the camp blacksmith they are often of hard maple. In the eastern part of the United States loggers generally choose a 36-inch handle, while on the Pacific Coast where large timber is felled, the lengths range between 38 and 40 inches for the average size timber, up to 44 inches for the massive redwoods. Handles for double-bitted axes are straight in order that either bit may be used. They are made in the same lengths as those for single-bitted axes.

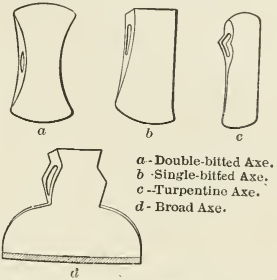


FIG. 12. — Characteristic Types of Ax Heads.

Single-bitted ax heads cost from 60 to 75 cents each; double-bitted ax heads from 80 cents to $1.

A straight-grained ax handle of the best quality costs from 20 to 25 cents; a turned handle, from 7 to 10 cents.

Broadax.—The broadax is used for hewing timbers and cross-ties, and performing like work. The more common form has a reversible bit, $11\frac{1}{2}$ or 12 inches long, a heavy square poll and a flat inner face. It may be used either right-handed or left-handed. The outer side has a slightly concave face and a cutting bevel $\frac{3}{4}$ of an inch wide on the bit. The usual weight of the head is 6 or 7 pounds. Handles are preferably of second-growth hickory and are from 26 to 36 inches long with a slight upward curve immediately behind the eye which enables the workman to assume a more upright position and still retain a correct cutting angle for the blade.

Turpentine Ax. — A special form of ax is used in southern pine forests for cutting the "boxes" or receptacles in the bases of the trees in which the crude turpentine is collected.

It is made in two patterns, namely, the square poll and the round poll, the type used being a matter of personal choice. The chief feature of a turpentine ax is a long, narrow bit which

enables the cutting of a deep but narrow incision. The usual dimensions are: length, $11\frac{1}{2}$ or 12 inches; width of blade, $3\frac{1}{2}$ inches. The weight averages $5\frac{1}{2}$ or 6 pounds. Straight hickory handles 36 inches in length are considered best.

SAWS

Saws are made in a variety of lengths and widths of blade, and in numerous shapes and patterns of teeth to meet special requirements and to conform to the preferences of certain localities.

The Blade.—In small- and medium-sized timber a 6- to $6\frac{1}{2}$-foot saw is commonly used, while for the fir timber of the Pacific Coast the saws range in length from 8 to 10 feet, with a maximum length of 18 feet in the redwood region. The width varies with the pattern of the saw, and ranges from 4 to $8\frac{1}{2}$ inches.

A slightly curved saw blade is most frequently used because it affords a larger space for sawdust. This makes it run with less friction and the work is less fatiguing. In order further to reduce friction, saws are usually made thinner at the back than at the cutting edge. Saws made for felling large Pacific Coast timber are often more limber than those used for log-making, because the latter are operated by one man and a stiff saw is needed to prevent the blade from buckling on the forward stroke.

The price of a saw is governed by its length and the quality of steel. The following prices are approximate:

Length in feet.	Price per single blade.
$6\frac{1}{2}$	\$2.85– 3.50
8	3.50– 4.50
10	6.00– 8.00
12	9.00–10.00
18	15.00–16.00

Handles. — The handles used on cross-cut saws are round, about $1\frac{1}{2}$ inches in diameter, and range in length from 12 to 18 inches. They are fastened either by clasps which fit into holes in the ends of the saw, or by loops which fit over the ends of the

saw and are tightened by a screw inside the handle. Either form permits ready removal from the blade. Handles cost from 15 to 75 cents a pair, the average price being about 25 cents.

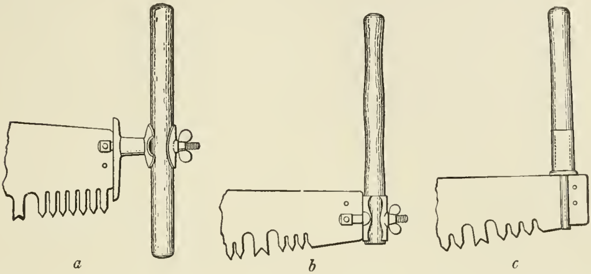


FIG. 13. — Common Types of Cross-cut Saw Handles. *a.* Reversible saw handle used in the Pacific Coast forests. *b.* Climax pattern saw handle. *c.* Hoop handle.

Teeth. — The teeth on a cross-cut saw are arranged in pairs, trios or quadruplets, each set of which is usually separated by a cleaner or raker for removing the sawdust. Where skilful filers are not available a saw without rakers is used, the sawdust being carried out of the cut by the teeth. The forms of teeth preferred are as follows: yellow pine, cypress and spruce — perforated lance teeth, arranged in sets of four (Fig. 14a); white pine, hemlock and cedar — broad teeth in sets of two (Fig. 14b); poplar and cottonwood — heavy solid teeth in twos (Fig. 14c); redwood — solid lance teeth in twos (Fig. 14d); Douglas fir — solid lance teeth in fours (Fig. 14e); white oak — solid teeth in sets of three (Fig. 14f).

The cutting teeth constitute a series of knives which strike the fibres at right angles and sever them on either side of the cut. The cleaners or rakers free the severed fibres which are then carried out in the cavities of the teeth in the form of sawdust occupying about six times as much space as the fibres did previous to cutting. Long, stringy sawdust denotes a well-fitted saw.

Loose-textured and long-fibred woods are the most difficult to

saw because the teeth tear rather than cut the fibres, a larger quantity of sawdust is produced, and the rough character of the walls of the cut offers great resistance to the saw. Coniferous wood is more readily sawed than hardwood, because of its simple anatomical structure and fine medullary rays.

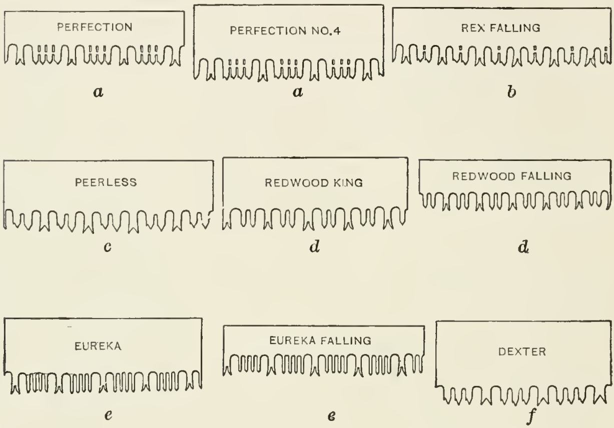


FIG. 14.—Saw Teeth Patterns. *a*. Often used for sawing yellow pine, cypress and spruce. *b*. For sawing white pine, hemlock and cedar. *c*. For sawing poplar and cottonwood. *d*. For sawing redwood. *e*. For sawing Douglas fir. *f*. For sawing white oak.

Experiments made by Gayer[1] show the resistance to the saw across the fibres of green timber to be as follows, the resistance to beech being assumed as 1.

	Resistance to saw.
Scotch pine, silver fir and spruce....	0.50–0.60
Maple, larch, alder..................	0.75–0.90
Beech............................	1.00
Oak..............................	1.03
Aspen and birch.....................	1.30–1.40
Willow and poplar...................	1.80

[1] Gayer, Karl: Forest Utilization (Vol. V, Schlich's Manual of Forestry; trans. from the German by W. R. Fisher; 2nd ed.). London; Bradbury, Agnew and Company, 1908.

Saw-fitting. — The cutting edges of the teeth are beveled to a fine point, the degree of bevel depending on the character and condition of the wood.

The filing and care of saw teeth is called "saw-fitting," and requires skill and experience.

The tools that comprise a complete saw-fitting set for cross-cut saws are as follows:

1 combined tooth gauge, jointer and side file.

1 saw set.

1 tooth set gauge.

1 swage, or 1 set-hammer.

Several flat files.[1]

A set of filing tools costs from 50 to 75 cents.

Some of the essential features of a well-fitted saw are as follows:[2]

(1) All cutting teeth must be the same length so that each will do its share of the work.

(2) The rakers or cleaners should be not less than $\frac{1}{100}$ of an inch nor more than $\frac{1}{64}$ of an inch shorter than the teeth.

(3) The form of tooth bevel required depends on the character of timber that is being sawed. It should not be too flat for sawing frozen timber, very hard timber or wood that has many tough knots. (See Fig. 15.)

(4) All teeth should be filed to a sharp point.

(5) Saws require a certain amount of "set," which consists in springing out alternate teeth in one direction and the remainder in the opposite direction so that the saw will cut a kerf somewhat greater than the thickness of the blade. Dense-fibred and frozen hardwoods require the least set, while pitchy pine and soft broadleaf trees require the maximum. Only the minimum set required should be given because the greater the set the more power required to pull the saw.

[1] Flat files from 6 to 8 inches long are preferred by saw fitters. The life of a file depends on its quality; as a rule one good file will fit from 6 to 14 saws. They cost from 7 to 9 cents for a 6-inch file, and from 9 to 12 cents for an 8-inch file.

[2] See Saw Fitting for Best Results. E. C. Atkins & Co. Indianapolis, Indiana.

Saws may be fitted by a member of the saw crew or by a regular filer, who can fit from twelve to fifteen saws daily. Where a greater number is required the work of fitting may often be done to advantage in a filing shop at the camp.

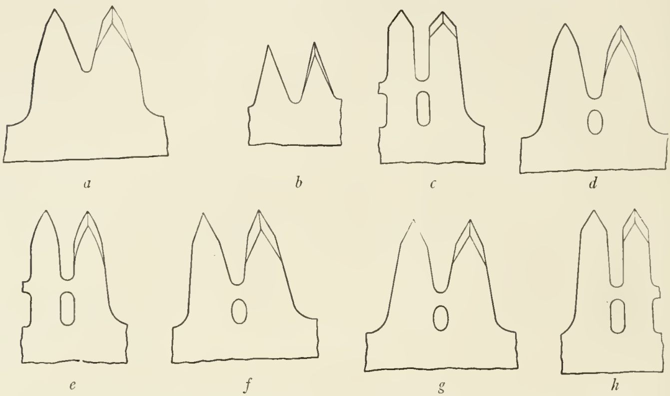


Fig. 15. — The Forms of Bevel used on Cross-cut Saws. *a.* Diamond point bevel, easy to maintain, and the point holds well. *b.* Bevel for a tooth where there are no rakers, the teeth cleaning out the sawdust. *c.* Bevel for knots and frozen timber where strength is needed in the extreme point — not adapted for fast sawing. *d.* Round point for fast, smooth sawing, in knotty timber. *e.* Bevel for fast, smooth sawing — teeth strong. *f.* Flat, thin bevel for soft wood and fast sawing — point is not as strong as that shown in *e.* *g.* Bevel adapted for general work. *h.* Bevel adapted for general work.

When the felling crew does the log-making, from one to two sharp saws are provided each day, otherwise a sharp saw is furnished every other day.

Saws filed daily are serviceable for a period of from two to four months and are then turned over to road-making crews and other laborers who do not require high-grade tools.

POWER FELLING MACHINES

There has not been a satisfactory power-driven tree-felling machine placed on the market. Machines of various types have been patented and offered for sale but they have not proved of practical value.

Among the devices invented in Europe was one consisting of a platinum wire stretched in a frame fitted with insulated handles. The wire was heated to white heat by an electric current and then applied to the bole of the tree through which it was designed to burn its way. It has never been introduced in this country.

Another device that was patented consisted of a chisel-like tool actuated by a power machine, which was intended to cut a channel through the tree.

Other devices such as drag saws and cross-cut saws operated by steam or gasoline power have been devised, but they have all been too heavy and bulky for transportation in the forest. Their weight is not only a handicap in getting the machine around through brushy woods and over rough bottom, but also prevents their rapid removal from the vicinity of falling timber where they are continually subject to damage.

POWER LOG-MAKING MACHINES[1]

On comparatively level land in an open forest composed of large trees, air-driven drag saws, called "steam dagos" have been used successfully for "bucking-up" logs.

The equipment consists of a traction engine with an air compressor and an air storage tank. The saws which may be attached readily to a log of any size are of the drag-saw type, driven by a piston working from a small cylinder, mounted on a metal frame weighing from 60 to 75 pounds. The cylinder is connected with the air chamber on the engine by a line of hose of sufficient length to give a working radius of 300 feet. Three frames and one saw are the usual equipment for an outfit.

Another type of log-making machine, patented in 1907, is known as the Endless Chain Saw. The essential features of the machine are an endless chain in which the links, represented by saw teeth shaped like those of a cross-cut saw, are riveted together. The backs of the teeth fit into sprockets. The chain is supported by a steel arm from 6 to 9 feet long, one end of which is pivoted to the frame carrying the machinery. This arm carries

[1] See page 100.

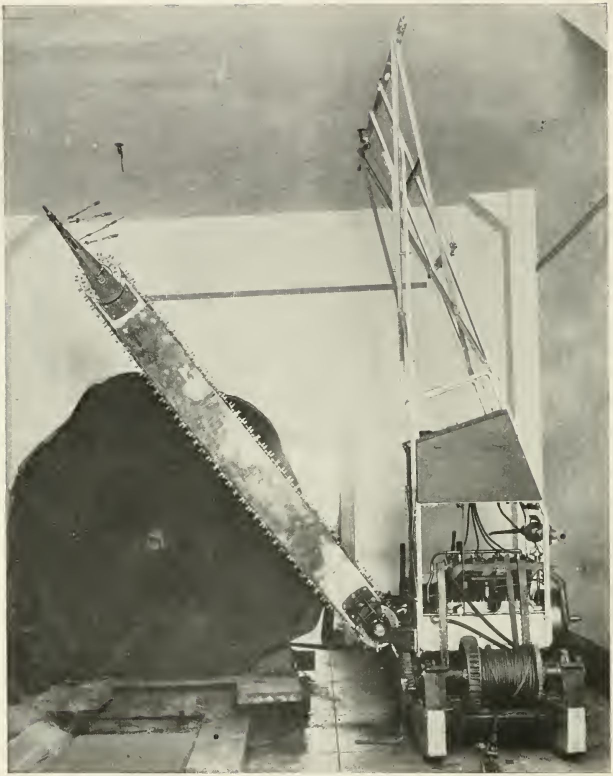


Fig. 16. — The Endless Chain Saw used in Bucking-up Logs in the Pacific Coast Forests.

a driving sprocket at the attached end and a blank sprocket at the free end over which the chain travels. The arm is raised and lowered by cables fastened to a light metal derrick which is mounted on the frame of the machine.

Power for driving the saw is furnished by a twenty- or thirty-five-horse-power, four-cylinder gasoline engine, directly con-

nected to the driving shaft of the saw. The machine is mounted on skids 13½ feet long, shod with a light steel rail on which the machine can be moved forward or backward for a working distance of 9½ feet. This permits a number of cuts to be made at each set-up of the machine.

The saw, mounted, weighs about 1200 pounds. The saw can cut at any angle up to 90 degrees and is run at a speed of 2500 linear feet per minute, cutting a kerf one-half inch wide. The manufacturers claim that the saw will sever a 6-foot log in four minutes. The largest log that can be cut is 8½ feet in diameter.

The machine is dragged about and logs are rolled over by means of a cable which is wound on a drum driven by the engine.

Jacks are used to level the track when the machine is used on uneven ground.

WEDGES

An essential feature of every faller's and log-maker's equipment is the wedge which is used to assist in directing the fall of trees and to prevent the binding of the saw in the cut. They are made either of metal or hardwood. Iron or steel wedges may be made by the camp blacksmith, or purchased from dealers in loggers' supplies at from 7 to 10 cents per pound.

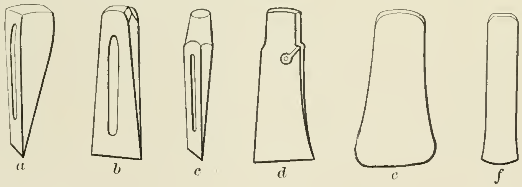


FIG. 17. — Some Patterns of Wedges used by Loggers. *a.* A wood chopper's wedge. *b.* Tie maker's and faller's wedge. *c.* Wood chopper's wedge. *d.* Faller's wedge. *e.* Faller's wedge, Pacific Coast type. *f.* Log-maker's wedge, Pacific Coast type.

The size and weight of metal wedges vary with the work for which they are used, and the pattern is largely a matter of individual choice. Felling wedges, especially when used in large

timber, are longer than those used for log-making. A common form of metal wedge used on the Pacific Coast by fallers is made from 1-inch steel and is about 13 inches long and 3 inches wide. In Maine the felling wedges are shorter and may be shaped somewhat like a hatchet head. They are 6 or 7 inches long, 3 inches wide at the base, and $1\frac{1}{2}$ inches wide and 1 inch thick at the top. On the Pacific Coast the buckers often employ a wedge similar to the one used for felling, although the length seldom exceeds 7 inches. In most regions fallers and log-makers use the same type of wedge.

Since smooth-faced metal wedges are likely to rebound, shallow grooves are often made on the faces so that when driven into a cut the pressure causes the wood to fill the groove and prevents any backward movement. The faces are sometimes roughened slightly with a cold chisel to accomplish the same purpose.

Hardwood wedges of hickory, hard maple, beech, ironwood, dogwood and persimmon are frequently used in the southern pine regions where timber for their manufacture is accessible. They are preferred because they are inexpensive and hold well in a cut. They may be made by the sawyers as needed or by contract at about 2 cents each. They are ordinarily 6 or 8 inches long, $2\frac{1}{2}$ or $3\frac{1}{2}$ inches wide and 1 inch in thickness at the head.

Felling crews in the Northwest usually carry two long and three short wedges; log-makers, five short ones. In other regions where the timber is of medium size the sawyers use from two to four wedges. From twenty to forty wooden wedges per month are required by a saw crew of two men.

Metal wedges are often carried by the fallers in a small canvas sack slung over the shoulder, or one is fastened at each end of a piece of hay wire, 3 or 4 feet long. Wooden wedges are carried in the pockets of the workmen.

MAULS AND SLEDGES

Iron wedges are generally driven by means of a wooden maul. These are made by the camp blacksmith from hard maple, yellow birch or any tough wood. A common form used in Maine is

made from a round tree section, 6 inches in diameter and from 26 to 30 inches long. An 8-inch head is left on one end of the section and the remainder is trimmed down to a diameter of 2 inches to form a handle. The head may or may not be bound with iron hoops to prevent splitting. Iron sledge hammers of 4 or 5 pounds' weight are sometimes used in place of mauls for driving metal wedges. Wooden wedges are driven either with an ax or a sledge.

SPRING BOARDS

These are used only in the Northwest, and serve as platforms on which notchers and fallers stand when performing their work. The spring board with the spur uppermost is

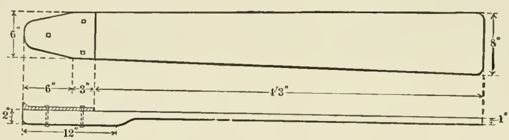


FIG. 18. — A Spring Board used by Fallers in the Northwest.

thrust into a notch cut into the tree and when weight is applied to the outer end of the board the spur is forced into the wood and prevents the board from slipping.

KILHIG OR SAMPSON

This tool is used as a lever to aid in directing the fall of a tree. It consists of a pole 3 or 4 inches in diameter and from 8 to 16 feet long, either sharpened or armed on one end with a spike. In operation the pointed end of the pole is placed in a notch in the tree trunk from 5 to 8 feet above ground. The free end projects downward to a point 10 or 12 inches above the ground where it is supported on a peavey handle or a pole the lower end of which is firmly planted in the ground. A laborer grasps the free end of the peavey handle and by pressing forward is able to exert a very strong pressure against the bole of the tree. Kilhigs are frequently made as needed by the saw crew since it

is easier to cut a pole than it is to carry one. This tool is in common use in the Northeast. There are several patent tools of similar character used in European forests but they have not met with favor in this country.

Fig. 19. — A Kilhig or Sampson used in Directing the Fall of a Tree.

MEASURING STICKS

The measuring sticks carried by log-makers are usually 8 feet long, where logs 24 feet and under are being cut. In the Northwest they are often 10 feet long. They may be made by the sawyers from a straight sapling with little taper, or by the camp blacksmith from squared sticks which are cut to exact length and on which marks are placed at two-foot intervals. Unless measuring sticks are metal-tipped, sawyers are apt to chop off one end when marking log lengths on the bole.

PEAVEY

The peavey is used as a lever to handle logs, and is an indispensable part of a logger's equipment. The standard maple or ash handle is 5, $5\frac{1}{2}$ or 6 feet long, but it may be made in special

lengths from $4\frac{1}{2}$ to 8 feet. There are two types, namely, the socket peavey and the clip peavey.

The handle of the first is fitted into a socket, which is armed on the lower end with a pike, and on the upper end of the socket is a clasp to which the hook is bolted.

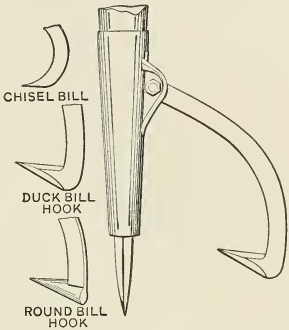


Fig. 20. — A Socket Peavey.

The second has a pike driven into the end of the handle, which is bound with a metal band to prevent the wood from splitting. The hook is attached to a clip or clasp independent of the pike.

The hooks are of three types, namely, "round bill," "duck bill" and "chisel." The round bill is preferred for summer work because it does not stick in the log; the duck bill is best for frozen timber as it will penetrate the wood more readily than the other forms; the chisel point is in limited use.

A peavey of standard form costs from \$1.25 to \$1.75.

CANT HOOKS

Cant hooks are used for purposes similar to the peavey, although they are employed more around mills and in handling sawed timber than in handling logs. Standard handles are $4\frac{1}{2}$, 5 and $5\frac{1}{2}$ feet in length. They are shod on the end with a heavy band of iron, carrying on its under side a "toe" which replaces the pike on the peavey. A hook of the same character as that on the peavey is fastened to the handle by a clasp.

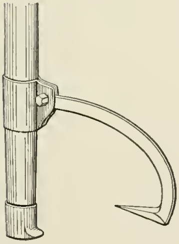


Fig. 21. — A Cant Hook.

A cant hook costs from \$1 to \$1.50.

PICKAROON

Laborers engaged in bringing cross-ties, stave bolts and other timber down steep slopes often use a pickaroon, which has a handle 36 or 38 inches long on the end of which is attached a head with a recurved pike. These heads are frequently made from worn-out ax heads by removing a portion of the cutting edge.

UNDERCUTTERS

The undercutter is a tool used by the "bucker" or log-maker in the Northwest. It serves as a support for the saw when making an undercut on a fallen tree.

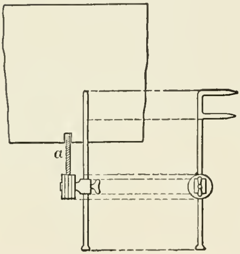


FIG. 22. — A Type of Undercutter used in the Pacific Coast Forests. *a* is the saw blade resting on the milled wheel.

It consists of a round or flat rod of iron about 2 feet long with a head on one end and single or double claws on the other. These claws are sharp and are driven into the side of the bole. Sliding on this rod is a block carrying a milled wheel which can be raised or lowered to accommodate the depth of cut, and on this the back of the saw rests. Buckers frequently dispense with undercutters because of the annoyance of carrying them.

USE OF KEROSENE

In felling coniferous woods resin collects on the saw and soon causes it to bind. This is remedied by the use of kerosene. Fallers and log-makers in the pine forests of the South carry a pint bottle of kerosene, fitted with a stopper made from green pine needles. The crew usually keeps a gallon can near at hand from which to replenish its supply. At frequent intervals the saw is sprinkled on both sides with the oil. A crew cutting from 12,000 to 15,000 feet log scale daily will use from one and one-half to three pints of kerosene. Four gallons per week is regarded as a liberal allowance.

CHAPTER VII

FELLING AND LOG-MAKING

SEASON

The period of the year in which felling is done is governed by climatic conditions and by the method of logging followed.

Where loggers rely on a heavy snowfall to furnish a bottom for transporting logs, felling begins in the late summer or early fall and continues until the snow becomes too deep for profitable skidding, which is about the middle or latter part of December.

On railroad operations in the Northern States felling is carried on throughout the greater part of the year, ceasing only when the snow becomes too deep for operation, or when deemed advisable because of market conditions.

In the coniferous forests of the South and in the Northwest felling is carried on the year round as weather conditions seldom interfere with logging.

Hardwood felling may continue throughout the year. Owing to the fact that the sapwood of species such as hickory is subject to insect damage[1] if cut during the summer months, the season of felling may be restricted to the resting period of the tree, although hardwoods can be cut safely at any season if they are manufactured in a short time and the lumber well piled and seasoned. The galleries made in sapwood by insects furnish

[1] Certain species of ambrosia beetles, sawyers and timber worms are very destructive to the sapwood of felled hardwood and coniferous timber during a portion of the year. The danger of attack is greatest in timber cut during the fall and winter and left on the ground or in close piles during the early spring and summer; also in trees cut during the warm season. The presence of bark is necessary for infestation by most of these insects and the danger can be largely avoided by not allowing the logs to accumulate during the danger season, or by barking such as cannot be removed within a few weeks. (A detailed discussion of these problems may be found in various publications of the U. S. Bureau of Entomology.)

the means of entrance for the spores of certain fungi[1] which cause a discoloration. The fungi develop most rapidly during warm, sultry weather. Summer-felled timber may be very seriously damaged by insects and fungi in from two to four weeks.

The felling time of trees, such as oak, is sometimes restricted to the late summer and early fall if the timber is to be transported by water because heavy species cut at this season and allowed to dry for from sixty to ninety days will float.

The logging of hemlock is restricted to the period between May and August, at which time only the bark can readily be removed. As it is a valuable by-product, used for tanning purposes, the logger cannot afford to cut the timber without saving the bark.

Tanbarks are also secured from chestnut oak (*Quercus prinus*) and from the tanbark oak of California (*Quercus densiflora*). The season for peeling chestnut oak is from early April until the end of June, and for tanbark oak, from the middle of May to the middle of July. The timber in both cases is now used for commercial purposes, although the bark is the more valuable product.

Coppice fellings should be made during the winter and early spring because the sprouts are then more thrifty than those from trees cut during the growing period.[2] Late winter felling is preferred because there is less chance for the bark to be loosened from the stool by the collection and freezing of moisture.

The season of the year in which timber is cut does not, so far as known, influence its strength, although it may affect its durability. Hardwoods are more complex in structure and are more easily damaged in seasoning than are softwoods. Winter-felled hardwood timber air dries more satisfactorily than summer-felled timber because the water content evaporates slowly and the woody structure adapts itself to the gradual shrinkage with a minimum amount of checking.

[1] There are several genera of fungi which attack the sapwood of deciduous and coniferous woods, causing a bluish, blackish or reddish discoloration. The infection takes place largely through spores carried by insects into the galleries that have been made by ambrosia beetles, sawyers and other borers.

[2] See Chestnut in Southern Maryland, by Raphael Zon. Bulletin No. 53, U. S. Bureau of Forestry, 1904, pp. 14–17.

DEADENING

Deadening or girdling consists in cutting a ring around the tree deep enough to penetrate to the heartwood. This ring is made just above the root swelling, approximately at the sawing point.

The deadening of trees reduces the water content of the boles and renders them lighter in weight. It is seldom resorted to with most species, because those which cannot be floated when cut in the ordinary way are either left standing or are railroaded to the mill. The greater part of the cypress timber will not float in a green condition, hence deadening or girdling is almost universal because a large per cent of the timber must be taken to the mill by water, due to the absence of railroad facilities. Even where cypress timber is railroaded it is usually girdled because (1) the logs will then float in the mill pond, (2) the sapwood is rendered somewhat tougher and skidding tongs do not pull out so readily, and (3) the heartwood in green timber swells during cutting and binds the saw.

Logging in cypress swamps is carried on at all seasons of the year and some girdle timber at any convenient time, although the sapwood is more subject to insect attacks at certain seasons. The greatest damage occurs during the months from May to September, inclusive.[1] Girdling, which precedes felling from a few weeks to several months, is generally done by contract for 7 or 8 cents per tree. One man will girdle about twenty-five trees per day.

DIRECTION OF FALL

This should be governed by the following factors:

(1) The lean of the tree. By the use of wedges a straight tree may be sawed to fall in any direction. Heavily leaning trees can be thrown by the same means in any one of three directions, namely, as it leans or to either side. Where a tree leans only slightly and its inclination cannot be determined readily by the eye, an ax handle held suspended like a plumb

[1] Hopkins, A. D.: Pinhole Injury to Girdled Cypress in the South Atlantic States. U. S. Bureau of Entomology, Cir. No. 82, 1907.

line between the line of sight and the tree will serve as an indicator.

In determining the direction of fall the choice is influenced by the shape of the crown. Very few crowns are symmetrical, one side often being heavier than the other, because of better light conditions. This preponderance of weight on one side acts as a powerful lever and, therefore, must be considered by the faller.

(2) The avoidance of lodging one tree in another.

(3) The selection of a spot where the bole will not be broken on stumps, rocks or other objects. This requires special attention in handling large or brittle timber. In yellow pine the loss from this source may be 1 per cent of the total, while in western red cedar it is often from 15 to 20 per cent, and in redwood even greater. Boles of the latter are sometimes so badly damaged in felling that they are worthless. A bed for redwood is frequently made by leveling the ground and covering it with brush.

(4) The simplification of skidding work. In brushy regions it is desirable to fell trees parallel to the skidding trail, since this aids the teamster in getting out the logs. Timber cut for snaking with power skidders should be felled away from or toward the direction of haul, especially if long timber is being handled, because it is difficult to drag out logs that are otherwise placed. Timber on slopes should be felled either up or down according to the location of the nearest accessible skidding trail. Trees felled up steep slopes are less subject to breakage because the distance of fall is less. It is, however, a more dangerous method because the trees may shoot down the slope.

ORGANIZATION OF CREWS

The organization of crews for felling and log-making differs in the various forest regions. Sawyers in the Lake States often work in crews of two under the direct charge of a saw boss, who keeps a close check on the work, assigns each crew to a given territory, specifies the length of logs and sees that waste does not occur in cutting. The logs are prepared ready for the swamper.

In southern pine operations a similar plan may be followed, the sawyers being responsible to the logging boss or to a contractor instead of a saw boss; or two or three saw crews may be in charge of a sub-foreman, called a "chipper and notcher," who notches trees for felling, marks off the log lengths, and keeps a record of the amount cut by each crew. The duty of the sawyers is to fell the timber and to cut it up into logs.

In Maine felling is often in charge of a sub-foreman called the "head chopper" who is the boss of a yarding crew, which includes two fallers, the swampers, teamster, sled tender and skidway man. The head chopper notches the trees, lays off the log lengths and directs the work of the yarding crew.

On the Pacific Coast notching, felling and log-making are often performed by separate crews. A notcher, who selects the trees to be felled and makes the undercut, is assigned to each yarding crew. Two fallers then cut the timber and the notcher marks off the log lengths for the guidance of the buckers who follow. The latter work singly, and two or three are required for each felling crew. On some operations a notcher is not employed, the undercut being made by the fallers.

The average day's work for two men felling, bucking and swamping lodgepole and other small timber, running from fifteen to sixteen logs per thousand, is from 4000 to 5000 feet; in small yellow pine timber, running from twelve to fifteen logs per thousand, from 7000 to 7500 feet, and where logs run from six to ten per thousand, from 10,000 to 15,000 feet. On the Pacific Coast an undercutter will notch from 30,000 to 50,000 feet of fir daily for a crew of fallers. Buckers average from 12,000 to 15,000 feet each.

Contract felling and log-making in lodgepole pine ranges from $1.25 to $2 per thousand feet; in yellow pine and cypress, from 35 to 50 cents; in fir, from 50 to 80 cents.

CUTTING AREAS

Sawyers working on a wage basis are seldom assigned to specific bounds, but cut where the foreman of the camp or the saw boss directs. In regions where the work is done by contract,

fallers may be assigned to definite bounds in order to facilitate the measurement of the cut timber.

NOTCHING

A wedge-shaped notch or undercut is made on the trunk in the direction of fall, to guide the tree and to prevent the bole from splitting before it is completely severed from the stump. It has a horizontal base extending slightly past the center of the

FIG. 23. — The Undercut on a Large Douglas Fir Tree. The fallers are standing on spring boards to enable them to make the cut above the root swelling. Washington.

tree if felling is done with the ax, and from one-fifth to one-fourth of the diameter when felling is done with the saw. The undercut on trees that lean heavily in the felling direction is made deeper than usual in order to insure a clean break. On those that lean away from the felling direction a small notch is cut because it gives the wedges greater power. In felling large redwood the sloping face of the undercut is sometimes made below the horizontal cut instead of above it in order to avoid

the waste of timber which would occur if the usual method were followed.

The notch should be placed about 4 inches below the point at which the felling cut is started on the opposite side. Its height above ground is determined entirely by the policy of the logger regarding stump heights. Notches are generally cut with the ax, but the horizontal cut may be made by a saw and the notch completed with an ax.

On small- and medium-sized timber the notch can readily be cut by a workman standing on the ground. On account of root swellings and defective and pitchy butts of the large Pacific Coast timber, it is the practice to cut the trees at a height of several feet above the ground. A form of scaffold must be provided for notching and felling large timber and for this purpose spring boards are generally used. In redwood logging where trees of very large size are cut the spring board may be replaced by a scaffold supported either on spring boards or timbers.

FELLING

With the Ax. — The ax was used almost exclusively as a felling tool during the early period of logging in the United States and is still used extensively for small trees. In felling with an ax, the operation begins by cutting a wedge-shaped notch opposite and slightly higher than the undercut. This cut is continued towards the center of the bole until the tree falls. Wedges cannot be used in felling with the ax, therefore, it is more difficult to throw a tree in any direction except that in which it leans. It is estimated that from 10 to 20 board feet per tree of spruce is lost when the ax is used exclusively for felling and log-making.

With the Ax and Saw. — This method is now almost universally used for medium and large timber because a loss of both time and wood occurs in using the ax alone. The use of a crosscut saw increases by about 10 per cent the number of trees a given saw crew can fell in a day.

The saw-cut is started on a level with or slightly above and opposite the undercut. When the saw has buried itself, wooden or iron wedges are driven in behind it to prevent binding. As

sawing proceeds the wedge point is made to follow the back of the saw by occasional blows. Sawing in a direction parallel with the undercut progresses until the tree begins to fall, whereupon one sawyer withdraws the saw and both seek a place of safety. On very large timber fallers first saw deeply on both sides of the undercut, then saw around the tree, making the last cut on the back side of the bole parallel to the undercut.

Trees with rotten hearts require different treatment from sound ones because the decayed bole is apt to give away before it is severed from the stump. A cut a few inches deep is made around the tree and then the bole is severed from the rear as in felling sound timber. Even if the bole gives away before the cut is completed it seldom splits badly. Felling during high winds is accomplished in the same manner. The direction of fall under either of the above circumstances often cannot be determined accurately, and the work is considered hazardous.

When timber is felled in a direction other than that in which it leans the faller leaves the most wood between the saw-cut and the undercut on the side opposite to that in which the tree leans. This tends to pull the tree in the desired direction.

STUMP HEIGHTS

There is no rule other than a commercial one regulating stump heights in different sections of the country. Loggers in early days cut very high stumps in order to avoid root swelling, pitchy butts and other defects.

The greatest waste from this source occurred in the Pacific Coast forests where stumps sometimes from 15 to 18 feet high were left by the early logging operators. Twelve thousand feet of merchantable timber per acre was not an excessive amount to be wasted in this manner. At the present time sound stumps seldom exceed 3 or 4 feet in height. Coniferous species, like western larch, often are so pitchy in the butt that from 4 to 6 feet must be left in the stump when the timber is to be transported by water. In the yellow pine forests of the South the stumps are cut from 16 to 24 inches high; in the spruce region of the Northeast they are often from 12 to 15 inches.

The tendency in all sections is to reduce the height of stump on sound timber to the lowest point practicable. It is not profitable to cut a low stump on most species when the butt is rotten, because a large portion of it may be trimmed off and thrown away during the process of manufacture. Saws cannot be kept as sharp on very low stumps as on those of medium height since grit dulls the saw, especially in a sandy soil. Sawyers cutting very low stumps cannot cut as much timber per day because the work is more fatiguing. The decrease in the cut of a saw crew due to low stumps may reach 15 per cent in medium-sized timber.

The general rule on the National Forests is that the stumps shall not exceed 18 inches in height. Lower stumps may be required at the discretion of the inspectors. The stump height on slopes should be determined at the contour line.

LOG-MAKING

Utilization of the Tree. — The bole is the most valuable portion of the tree except in such instances as the curly stumps of black walnut and other species which are highly esteemed for cabinet work. In many localities rough tops and limbs are cut to a diameter of from 2 to 4 inches for firewood, charcoal burning and destructive distillation. Faggots are not utilized to any extent in this country.

The portion of the bole utilized is influenced by the location of the timber with reference both to the manufacturing plant and to markets. The lumberman with accessible timber may be able to handle low-grade logs which an operator with a less favorable location could not handle profitably.

The transportation charge for carrying lumber to markets is also a powerful factor in determining the extent of utilization, inasmuch as all grades of a given species pay the same rate and where the latter is high, low grades cannot be shipped at a profit. An interesting example is that of the shortleaf and longleaf pines of the South. Both species are usually sold at the same price f.o.b. at a given mill, but since longleaf weighs more per

thousand feet, in some cases 300 pounds on a given item, the freight charge to market is greater and hence shortleaf can be shipped to more distant markets, or a lower average grade can be manufactured and the same profits secured as in the case of longleaf.

Crooks, knots, pitch, worm holes and other defects are factors that influence the amount of bole taken. The extent and character of the defects that a log may contain and still be merchantable is governed by the species and the use to which the timber is to be put. Chestnut lumber containing many "pinworm holes" has a market value both for veneer backing and for the manufacture of tanning extract if the timber is otherwise sound. On the other hand, oak with similar defects brings a low price because its physical properties do not fit it for many purposes. Defective logs of white pine, yellow poplar and other woods suitable for making high-priced box material may be utilized because the lumber is cut into short lengths and the unsound portions eliminated, while logs of yellow pine with similar or fewer defects are frequently valueless for this purpose because the wood is heavy, making higher freight charges on the package, and yellow pine crates, when placed in cold storage, taint dairy products, eggs and certain other foodstuffs.

The amount of bole taken depends on the ultimate use of the timber. This is well illustrated in cutting white oak for rived stave bolts which are split along the line of the medullary rays. Since the timber must be straight-grained and free from knots, only the choicest cuts are taken and a large part of the bole is often left in the forest.

Market conditions are a potent factor in regulating the minimum size and character of timber that can be handled profitably. High-grade logs produce a sufficient percentage of low-grade lumber to supply a dull market, while a brisk demand enables the logger to bring out a large per cent of his inferior material because it can be sold for enough to cover the cost of manufacture and yield a small profit. Close utilization will not be general until the public is prepared to pay higher prices for lumber.

Log Lengths. — Builders consider even lengths of from 10 to 24 feet most advantageous and these have come to be recognized in lumber markets as standard. Mills handling small- and medium-sized timber, which is skidded by animals, cut their logs into the above lengths in the forest, while those manufacturing long timbers or using power skidding machines either bring in logs varying from 24 to 60 feet in length or the entire bole to a top diameter of from 4 to 6 inches. These logs may be cut into shorter lengths at the railroad or landing but delivery at the mill of long logs or entire boles is considered more desirable since it precludes a loss in crooked timber by improper division in the forest. An experienced man at the mill can cut the boles into log lengths more rapidly and economically with a power machine than can the sawyer in the woods using a cross-cut saw, and special orders for unusual lengths can be filled without loss of time.

Logs to be rafted down large streams should be cut into long lengths because the raft can be built stronger and cheaper.

The transportation of long logs out of the forest is destructive to young growth because their length requires considerable swamping for animal transportation, and when a ground system of power skidding is used a large amount of young growth is broken or bruised before the log reaches the run down which it passes to the machine.

The "board" mills in the yellow pine region cut logs into standard lengths, a large percentage being 12, 14 and 16 feet. The "timber" mills cut longer logs to meet their special requirements.

Cypress operators who railroad their timber to the mill cut logs into standard lengths between 10 and 20 feet. On pull-boat operations where logs are floated to the mill the whole trunk or 30- to 50-foot logs are skidded.

Hardwood logs rafted down the Ohio River and other large streams are cut into lengths of from 40 to 60 feet, while on small streams and on railroad operations standard length logs are the rule.

In the Adirondacks spruce logs which are to be manufactured into lumber are largely cut into lengths of 10, 12, 13, 14 and 16 feet, and those for pulp manufacture into even lengths of 14 feet or more. In Maine spruce is cut either into standard lengths, or the butt cut is made from 30 to 40 feet long and the remainder left in a top log which is taken to a diameter of 4 or 5 inches.

White pine is largely cut into standard lengths.

Douglas fir on the Pacific Coast is cut into logs ranging in length from 24 to 60 feet and sometimes longer. The customary lengths range up to 40 feet with a high percentage of 32-foot logs. Fir is well adapted for the manufacture of long timbers, and supplies a large share of the demand for such material.

In the redwood region about one-fourth of the logs are cut 16 feet long. The remainder are cut into lengths of 18, 20, 24, 32 and 40 feet. The longer lengths are cut from the smaller trees.

Method.—The first step in log-making is to cut the limbs from that portion of the bole which is to be utilized. This is done with an ax by a member of the saw crew or by a special man called a swamper, knotter or limber. The bole is then laid off into log lengths by the head sawyer or by the "chipper" who uses an 8-foot or 10-foot measuring stick.

In log-making there are several problems which the workmen must solve depending on the position of the felled tree.

(1) When the log lies flat on the ground, bucking-up is a simple matter as the sawyers start their cut on the lower or upper part of the bole at the marked point and continue until the log is severed from the bole. When the saw begins to bind wedges are driven into the cut and made to follow the saw by an occasional blow from an ax or maul.

(2) When the bole is supported at one end, care must be exercised to avoid splitting slabs from the under side. This is accomplished by making a cut 2 or 3 inches deep on the under side of the bole. In addition the log may have its free end supported by a false work of logs, or by a heavy stick placed in a vertical position directly under it. The saw-cut is then started

on the upper face and continued until the log breaks off from its own weight.

(3) When the bole is supported at both ends the cut is usually started on the under side and continued until it extends one-half or two-thirds of the distance through the log. A cut is then started on the upper side of the bole and continued until the log is severed. The bole is often supported by heavy sticks placed in a vertical position under both sides of the cut.

(4) When the bole is sprung between trees or stumps the general practice is to make a deep cut on the concave face and then to saw or chop on the outer face. Caution is required where trees are badly strained because they may break with considerable force and injure the workmen.

In small- and medium-sized timber it is generally the duty of the felling crew to cut the bole into logs as soon as the tree has been felled. An exception to this occurs where the bark of trees such as hemlock, chestnut oak and tanbark oak are sought for tanning purposes. In this case the felling of the trees and the stripping of the bark are done by a crew whose work may precede the actual logging operation by several weeks. Log-making under these circumstances is often done by a separate crew.

Log-making in the large timber of the Pacific Coast has been developed along special lines. The large size of the timber prevents the use of a two-man crew unless a scaffold is constructed on which the men can stand. This is not necessary because one man with a 7- to 9-foot single-handled saw can cut logs to advantage by standing on the ground. He starts his cut with the saw at an angle and gradually brings it towards the horizontal as it nears the bottom of the log. Thick-barked timber requires special preparation before bucking-up because the bark is a great hindrance to the bucker. The practice in redwood forests is to remove the bark from the log and when the refuse is dry to burn over the area. Bucking-up is then carried on by one man as described. The bark on Douglas fir logs tends to dull the saw and is removed along the line of the saw-cut.

Wedges are used to keep the saw from binding and kerosene is applied to the saw blade when necessary to free it from pitch.

The equipment used for felling and log-making in medium-sized timber consists of a cross-cut saw, $6\frac{1}{2}$ feet long, with two detachable handles; a double-bitted or single-bitted ax; two or more wooden or iron wedges; a measuring stick; a bottle of kerosene; and possibly a wooden maul or a sledge for driving wedges.

Similar equipment is used for large timber but the saws range in length from 8 to 18 feet. Spring boards are also required where high stumps are cut.

Power Bucking. — In the sugar pine forests of California hand bucking is sometimes supplemented by the use of the power-driven "steam dago."[1] The engine is moved under its own power to the vicinity of the felled trees which are to be cut into logs. A saw frame and saw are adjusted at the cutting point on the bole, the saw is then started and left to work automatically while two other frames are being adjusted at other cuts. Saws are run at about 150 strokes per minute.

A swamping crew precedes the saw crew and trims the felled trees, throwing the brush to one side to give room for the machines. There is a decided economy both of time and labor in the use of the compressed-air machine. Nine men are required to operate it and the daily capacity is from 125,000 to 140,000 board feet, with a maximum output under favorable circumstances of 160,000 feet. From fifteen to seventeen men would be required to secure the same output with hand labor, and the labor charge would considerably exceed the cost of operation and maintenance of the machine. Some difficulty is experienced in operating during cold weather because the moisture freezes on the cylinder and piston and interferes with the action of the latter.

The endless chain saw[1] is used to cut logs into shingle-bolt lengths in the redwood forest region and also to cross-cut logs at the mill. It is especially adapted for the former work,

[1] See page 79.

where very large timber is to be cut into short lengths, because several cuts can be made at each set-up of the machine.

WASTE IN LOG-MAKING [1]

Inefficient saw crews under improper supervision often cause a waste of timber by careless selection of log lengths.

Crooks. — Waste nearly always occurs in the division of crooked boles. Crooks are more serious in small than in large timber because the percentage of loss in slabbing at the mill is much greater. Pronounced sweeps should be cut from the bole and left in the woods and where the crook is not deep it should be left on the end of the log where there will be the minimum loss in manufacture. Crooked logs are more expensive to handle both in the forest and at the mill than straight logs of the same diameter and length because more time is required to skid, to load on to the log cars and to handle them in the mill, and the actual output secured is often from 20 to 75 per cent less.

Forked Trees. — Another source of waste is the cutting up of forked trees. The chief faults of the sawyers in this regard are:

(1) Felling the tree so that the lower fork is either imbedded in the ground or so placed that it is difficult to saw it properly. The line of least resistance is followed and the lower fork is left or a portion of it sacrificed. (Fig. 24.)

(2) Cutting too far below the fork, thereby wasting merchantable material.

(3) Cutting too far above the crotch, as shown in Fig. 24. The bole should have been cut close up on both sides of the crotch and the short section left in the woods.

It is unprofitable to bring logs with big forks to a mill because the yield of lumber from them is not in proportion to the cost of production. Forked logs require from two to fifteen times longer to get into the mill and to be sawed into lumber than do straight logs of the same diameter and length, and the yield from them is often from 20 to 50 per cent less. A further loss is

[1] See Prolonging the Cut of Southern Pine, by H. H. Chapman and R. C. Bryant. Yale University Press, New Haven, Conn., 1913.

occasioned by the reduction of the mill output because of the additional time spent on sawing such logs.

Improper Trimming Lengths. — Sufficient attention is not paid to the length into which logs are cut. They should be a few inches longer than the standard because in sawing large logs it may be impracticable for the sawyers to cut exactly at right angles to the length and, further, logs are often damaged on the ends in skidding and in transit to the mill. This extra length is trimmed off in the mill and gives a straight, bright end on each

Fig. 24. — A Forked Tree cut in a Wasteful Manner.

board. Three inches are regarded as sufficient for a log 16 inches and under in diameter and 4 inches for those of greater diameter.

Workmen become careless and often do not cut 50 per cent of the logs of the proper length. Where less than 2 inches is left for trimming length, the board is usually reduced 2 feet in length at the mill, while on boards that are several inches too long the loss is also great. Inaccuracy in measurements is due to careless marking with the stick and to the use of a measure shortened by accidentally chipping off the end with the marker's ax.

The result of measuring 1000 logs on the skidway of a southern yellow pine operation showed that only 426 logs were of the proper length, while 240 were too short and 333 were from 1 to 11 inches too long. The excess on the ends of several logs was often sufficient to have secured an additional 2 feet of merchantable material had the bole been carefully divided.

Disregard of Quality. — Log-makers frequently do not give sufficient attention to securing quality as well as quantity. Where timber has large limbs the general practice is to leave the greater part of the tops in the woods because lumber of low grade only can be secured from them. Log-makers frequently exercise poor judgment in cutting trees into logs and often fail to apportion the bole so that the best portion and the knotty portion are kept in separate logs. It is not uncommon to find from 6 to 10 feet of clear bole put into a log with several linear feet of knotty material. This policy is costly because the value of the log is largely determined by its poorest section. The universal rule should be to divide the bole so that the clear material will be kept separate from the rough and defective. It may often prove more profitable to waste a few feet of rough log if by so doing the amount of high-grade lumber can be increased.

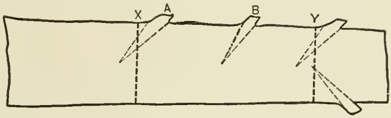


FIG. 25. — Waste in a Top resulting from an Improper Selection of Log Lengths.

Waste. — One form of waste commonly observed is shown in Fig. 25. Log-makers seldom go above points where one or more large limbs project out on one side (see X). If the log is 15 or more inches in diameter and one side is free from knots, the cut should be extended 2 or 4 feet further up the tree, say to "Y," if that distance gives the proper log length. The lower side will yield clear lumber free from knots and cannot in any way depreciate the value of the log content, while the lumber-

man secures the additional material on the good half of the log which otherwise would be wasted. If necessary, the portion containing the large knots can be cut off in the mill by the trimmer.

A loss usually occurs in cutting broken timber into logs by making the saw-cut too far below the break. Where the break is not square across it is often possible to obtain added material by cutting the log so as to include a portion of the broken end. This should always be done on large timber where the extra section that can be secured is at least equal to one-half the diameter of the log.

One of the most extensive wastes occurs in the tops when all of the merchantable material below the larger limbs has not been utilized. Sections of good timber from one to several feet in length and of a quality equal to that taken are often left, usually because the log-makers did not exercise judgment in dividing the bole into the most economic log lengths. The loss from this source often runs from 3.5 to 5 per cent of the total merchantable stand and the annual loss on large operations amounts to thousands of dollars, although it could be corrected by proper supervision.

Close utilization of the kind mentioned does not require the operator to take material that he does not consider merchantable. A system by which timber is cut for quality as well as quantity means an increase in the percentage of the higher grades, more timber per acre and prolonged life to the operation.

BARKING OR ROSSING

Where logs of large size are skidded on dry ground, the bark on the lower side is frequently removed to reduce friction. This is termed "barking" or "rossing." During a wet season or when power is used for skidding, rossing is frequently omitted.

In the Northeast the ends of long logs that are being yarded on drag sleds are sometimes rossed on the under side when the road is either level or upgrade, or the dragging hard.

In the Pacific Coast forests during the season when the bark does not peel readily, the work is done, usually with a broad-

ax, by a special member of the logging crew. During other seasons a "spud" or peeler may be used.

In other sections of the country only the largest logs are rossed. The work is generally done with an ax by a member of the swamping crew. On heavy timber the barker not only removes the bark but also straightens slight crooks by cutting off sufficient wood to flatten the log so that when dragged, it will remain in proper position.

Spruce logs intended for pulp manufacture are sometimes entirely rossed in the forest because there is less wood wasted than when the work is done by machinery at the mill.

Redwood logs are always rossed in the forest before the boles are made into logs because the thickness of the bark and its rough character not only impede log-making but are also a hindrance in transportation.

SNIPING

Previous to skidding, the forward end of a large log is "sniped" or "nosed." This consists of rounding off the under side of the log so that it will not catch on obstructions. Where the ground is rough and the log is likely to roll over, the entire front end is sniped. This work may be done by a sniper or by one of the swampers. The sniper generally prefers an ax with a 5- to 6-pound head.

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CHAPTER VIII

MEASUREMENT OF LOGS AND OTHER FOREST PRODUCTS

UNITS OF MEASUREMENT

The common method of measuring the contents of logs is by the board foot, although volume standards are also in use.

Firewood, acid wood, pulpwood, excelsior wood, stave bolts, spool wood and novelty wood are ordinarily measured by the cord (page 114). Some products such as hoop poles are sold by the hundred or thousand pieces; posts and poles are measured by the linear foot, thousand board feet, or piece; shake and shingle-bolt material either by the cord or by the thousand board feet; mine timber by the piece, linear foot or board measure; crossties by the piece or thousand board feet.

Cubic measure is occasionally used in some parts of the country for the measurement of high-priced vehicle woods, fancy hardwoods, red cedar pencil stock, pulpwood and, in the South, for export timbers.

The metric system was adopted in the Philippine Islands some years ago, but it is not used in the United States.

BOARD MEASURE

Although board measure is designed primarily for the measurement of sawed lumber it is also a common method for expressing the volume of logs. When used for this purpose it does not show the actual contents of the log but the estimated amount of sawed lumber that sound, straight logs of specified lengths and diameters will yield.

The board foot is a section 12 inches square and 1 inch in thickness. Although it is based on a thickness of 1 inch, in practice it is applied to sawed material greater than 1 inch in thickness, the contents being in proportion to their relation to the unit. In most sections lumber is cut scant in thickness and

width, a practice now recognized by the Courts. A large percentage of construction lumber is surfaced, and the basis of measurement is the size of the rough board from which it is manufactured. In many regions the required thickness of 1-inch lumber surfaced on one or two sides is $\frac{13}{16}$ of an inch, although in some sections it is $\frac{25}{32}$ or $\frac{14}{16}$ of an inch. The widths vary with the character of the product and the width of the board; for example, the size of a so-called 2-inch by 4-inch scantling, surfaced on one side and one edge, which is standard with manufacturers, is $1\frac{5}{8}$ inches by $3\frac{5}{8}$ inches, while a 2-inch by 12-inch plank, surfaced on one side and one edge, is $1\frac{5}{8}$ inches by $11\frac{1}{2}$ inches. One-inch flooring and like products are usually surfaced to $\frac{13}{16}$ of an inch in thickness, and $2\frac{1}{4}$ inches, $3\frac{1}{4}$ inches and $5\frac{1}{4}$ inches in width, exclusive of the tongue. The buyer pays for the rough lumber from which the finished product was made, namely, for a 3-inch, 4-inch or 6-inch rough board, and the purchase of 1000 feet of such material secures a quantity which covers 750, 812 and 916 square feet, respectively, if there is no waste in laying.

The reasons which have led to the custom are the saving in timber effected by the manufacturer, and the impossibility of cutting all boards of exactly the same width and thickness. The latter would be useless, even if possible, because of the uneven shrinkage in seasoning of boards of a given size, and lumber scant in thickness is fully as serviceable for the majority of purposes as it would be if manufactured full thickness.

Lumber less than $\frac{13}{16}$ of an inch in thickness and veneers are usually sold surface measure. Lumber quotations made on the basis of the thousand feet are often assumed to refer to board feet, which they do not unless so specified.

LOG RULES [1]

Contents of logs are chiefly calculated in board feet according to some specified log rule. Many different rules are in use in the

[1] For a detailed discussion of log rules see Bulletin 36, U. S. Forest Service, The Woodsman's Handbook, by Henry Solon Graves and E. A. Ziegler; also Forest Mensuration, by Henry Solon Graves. John Wiley and Sons, New York, 1906.

United States and there is a wide variance among them in the contents shown for logs of a given size. Some rules are based on mathematical formulas; some on diagrams which show the number of boards that may be cut with an assumed allowance for slabs and saw-kerf; others on actual tally at the tail of the mill; while certain ones are a combination of two of the above methods.

Many of the present rules were prepared years ago when logging and milling methods were not as efficient and intensive as they are to-day. There are only two rules, namely, the International and the Champlain, which give results closely approximating the sawing contents of logs and these are in limited use. The discrepancy in any rule, however, is not of great moment if its deficiencies are fully understood by all the parties interested in the measurement of a certain lot of logs.

International Rule.[1] — This rule is designed for the measurement of logs which are to be cut by a band saw.

The rule is based on the formula:

$$Bf = 0.22\,D^2 - 0.71\,D,$$

in which Bf represents the yield in board feet, D the top diameter inside the bark, $0.22\,D^2$ the contents in board feet of a 4-foot section less a deduction for saw-kerf and shrinkage in seasoning and $0.71\,D$ the waste incident to square edging and to normal crook.

The formula is based on the following principles:

(1) The saw-kerf is $\frac{1}{8}$ inch.

(2) The loss from shrinkage and unevenness in sawing is $\frac{1}{16}$ inch.

(3) The minimum board considered is not less than 3 inches wide and contains at least two board feet.

(4) The taper of logs is $\frac{1}{2}$ inch for each 4 feet of length.

(5) The average crook in first-class logs is 1.5 inches and does not exceed 4 inches in a 12-foot log.

[1] A copy of this rule is given in the Appendix.

The rule may be applied where saws are used which cut a kerf greater or less than $\frac{1}{8}$-inch by adding or subtracting the percentages given in the following table:

For $\frac{7}{64}$-inch kerf add	1.3 per cent.
For $\frac{3}{16}$-inch kerf subtract	5.0 per cent.
For $\frac{1}{4}$-inch kerf subtract	9.5 per cent.
For $\frac{5}{16}$-inch kerf subtract	13.6 per cent.
For $\frac{3}{8}$-inch kerf subtract	17.4 per cent.
For $\frac{7}{16}$-inch kerf subtract	20.8 per cent.

A test of this rule in a white pine mill in Canada showed an overrun of 0.4 of one per cent on 403 logs which ranged in diameter from 6 inches to 33 inches.

Scribner Rule.[1] — This rule, which is the oldest now in use, was constructed from diagrams showing the number and size of boards that could be sawed from logs of specified diameters after allowing for waste. The contents of these boards were then calculated for different lengths and the table built up from the results.

The common form of the rule now in use is called the Scribner Decimal "C" rule. This differs from the original in that the units are dropped and the values rounded to the nearest ten. Thus ninety-seven board feet would be written ten, and ninety-four board feet, nine. The original rule did not give values below 12 inches but the table has been extended and now includes diameters from 6 to 120 inches.

There are in use among lumbermen three different extensions of the rule below 12 inches, known as the Scribner Decimal "A," Scribner Decimal "B" and Scribner Decimal "C."

The Scribner Decimal "C" rule has been adopted as the standard for use in the National Forests and is the legal rule in Minnesota, Idaho, Wisconsin and West Virginia.

It gives fair results for small logs cut by a circular saw but is too low for logs over 28 inches in diameter. In sound logs the mill scale overruns the Scribner Decimal "C" rule by from 10 to 20 per cent.

Doyle Rule.[1] — This rule is used in many sections of the country and, except in Texas, it is the common rule in the pine

[1] A copy of this rule is given in the Appendix.

forests of the South. It is the legal rule in Arkansas, Florida and Louisiana.

The Doyle rule is based on the formula

$$\left(\frac{D-4}{4}\right)^2 \times L,$$

in which D equals the diameter in inches of the log at the small end and L the length of the log in feet.[1] A uniform allowance of 4 inches is made for slab. This is too great a deduction for small logs and it is insufficient for large ones, consequently the mill tally overruns the scale on small logs and barely holds out on the large ones.

A rule-of-thumb method for determining the contents of logs by the Doyle rule is to subtract 4 from the diameter and square the remainder. The result is the volume in board feet of a 16-foot log. Other lengths are in proportion. This short-cut method often proves of value to the field man since the contents of logs can readily be determined by mental calculation.

In southern yellow pine the mill cut overruns the log scale by from 18 to 25 per cent.

Doyle-Scribner Rule. — This rule is used for scaling hardwoods and occasionally for southern yellow pine. It is a combination of the two preceding rules. The values for diameters up to and including 27 inches are from the Doyle rule and those for 28 inches and over are from the Scribner rule. This combines the lowest values of each rule, and is, therefore, not as accurate as either alone.

The Maine or Holland Rule.[2] — This has been the principal rule in Maine for many years and is not used elsewhere to any extent. The values have been determined from diagrams showing the number and size of 1-inch boards, 6 inches and over in width, that can be sawed from a given log.

Sound spruce and pine logs of good quality, from 12 to 18 feet

[1] In some cases the published rule gives results varying nearly 3 board feet from those determined by the use of the formula. The discrepancies do not appear to bear any relation to a definite method and are undoubtedly due to errors which have crept in since the rule was made.

[2] A copy of this rule is given in the Appendix.

in length, when cut by a circular saw which removes a $\frac{1}{4}$-inch kerf, will yield approximately the amount of inch-lumber shown by the rule.[1]

It is regarded as a satisfactory rule for short logs.

The Herring or Beaumont Rule. — This is the rule in common use in Texas. The tables are based on the measurement of logs sawed at the mill. The original rule applied to logs from 12 to 42 inches in diameter and from 10 to 60 feet in length. An extension of the rule down to 6 inches was made a few years ago and the combination is known as the Devant-Herring rule.

This gives higher values than the Doyle rule for logs 15 inches and under in diameter, but gives much lower values for larger logs. It gives results closer to the actual sawing contents of small logs in the shortleaf-pine belt of Texas than does the Doyle rule, since the average logs are less than 15 inches in diameter.

The Nineteen-inch Standard Rule.[2] — This rule is based on volume measure, the unit being a log 13 feet long and 19 inches in diameter inside the bark at the small end. This is called a "standard" or "market." The formula for determining the volume is

$$V = \frac{D^2}{19^2} \times \frac{L}{13},$$

in which V equals the volume, D the diameter inside the bark at the small end and L the length in feet.

Standards are not convertible into board feet by any common factor since the smaller the log, the greater the number of standards required to equal 1000 board feet. A converting factor of 200 feet per standard is often used, but it gives inaccurate results since it requires from 4 to 14 standards to yield 1000 board feet, depending on the diameter and length of the sticks.

The ratio between cords and standards is fairly constant for logs of equal length. In the Adirondacks 2.9 standards are considered equal to a cord.

[1] See Manual for Northern Woodsmen, by Austin Cary, p. 135. Harvard University, Cambridge, Massachusetts, 1909.

[2] A copy of this rule is given in the Appendix.

This rule is used in Northern New York and is regarded favorably for the measurement of pulpwood.

The New Hampshire or Blodgett Rule.[1] — This rule is based on a cubic foot having an arbitrary value equal to 1.4 English cubic feet. The unit is a log section 16 inches in diameter and 1 foot in length. The formula for determining the contents of a log of a given diameter and length is

$$V = \frac{D^2}{16^2} \times L,$$

in which V is the volume in cubic feet, D the diameter in inches and L the length in feet.

It is more satisfactory for pulpwood measurement than for board feet because small logs are overvalued and large logs undervalued. When converting the results into board measure, 115 cubic feet are assumed to be equal to 1000 board feet when the diameter is taken at the middle of the log, and 106 cubic feet when the diameter is taken at the small end. It is impossible, however, to convert a volume measure into board feet by means of a constant factor because of the wide variation in the relation between volume and board feet when logs of different diameters and lengths are considered.[2]

The above rule is commonly used for spruce in Maine, New Hampshire and Vermont.

Gobel Cube Rule. — This is sometimes called the Big Sandy rule, and is largely used for scaling logs along the Ohio River and tributaries near the Big Sandy River.

The unit is a log section 18 inches in diameter and 1 foot long, which is assumed to be the smallest that will cube 12 inches.

The formula is

$$V = \frac{D^2}{18^2} \times L,$$

[1] A copy of this rule is given in the Appendix.

[2] For a detailed discussion of this subject see The Log Scale in Theory and Practice, by H. D. Tiemann, Proceedings of the Society of American Foresters, Vol. V., No. 1, pp. 18–58; and The Standardizing of Log Measures, by E. A. Ziegler, Proc. Soc. of Am. For., Vol. IV, No. 2, pp. 172–184.

in which V is the volume in cubes, D the diameter in inches and L the length in feet. One cube is assumed to be equal to 12 board feet.

CUBIC MEASURE

The chief use of the cubic measure is for the determination of the contents of logs which, with the exception of the bark, are used in their entirety, such as for pulpwood, excelsior wood and rotary-cut veneer stock.

The methods most commonly used are as follows:

Method of Cubing Logs by the Measurement of the Length and Middle Diameter. — The volume of a given log is determined by the formula

$$V = AL,$$

in which V is the volume in cubic feet, A the area in square feet of the middle cross section and L the length in feet.

This method is simple and it is easy to secure the measurements provided the middle of the log can be reached.

Method of Cubing Logs by the Measurement of the Length and Both Ends. — This requires one more measurement than the former and hence is not so rapid. It is adapted for use where the middle diameter cannot be secured.

The formula for determining the volume is

$$V = \frac{B + b}{2} \times L,$$

in which V equals the volume in cubic feet, B and b the area in square feet of the large and small ends, respectively, and L the length in feet.

Cord Measure. — The standard cord contains 128 cubic feet of stacked wood, or a pile 4 feet wide, 4 feet high and 8 feet long. In some parts of the country, especially in the Middle West, firewood is often sold by the "rick," which is a stack 4 feet high, 8 feet long and usually 12 or 16 inches wide. A stack of the same height and length and 24 inches wide is sometimes called a "single cord."

Although a standard cord contains 128 cubic feet of stacked wood, the solid cubic contents are extremely variable, depending

on the length, diameter, form, species and degree of dryness of the sticks.[1]

(1) *Length of Sticks.* — Since sticks are never entirely smooth or straight there are always spaces between them when they are piled. The amount of air space increases in proportion to the length of the sticks. Thus, assuming a 4-foot stick as standard, 1-foot sticks show an increase in solid volume of 8.3 per cent, while 6-foot sticks show a decrease of 5.5 per cent.

INTERDEPENDENCE OF THE STICK LENGTH AND THE VOLUME OF SOLID WOOD PER 128 CUBIC FEET OF SPACE[1]

Length of stick, feet.	Straight sticks.		Crooked sticks.		Knotty sticks.	
	Volume, cubic feet.	Difference, per cent.	Volume, cubic feet.	Difference, per cent.	Volume, cubic feet.	Difference, per cent.
1	99.81	+8.3	93.47	+14.1	89.60	+20.7
2	97.28	+5.5	89.60	+9.4	84.48	+13.8
3	94.72	+2.8	85.76	+4.7	79.36	+6.9
4	92.16	0.0	81.92	0.0	74.24	0.0
5	89.60	−2.8	78.08	−4.7	69.12	−6.9
6	87.04	−5.5	74.24	−9.4	64.00	−13.8

[1] Muller, Udo: Lehrbuch der Holzmesskunde, Leipzig, 1902.

(2) *Diameter of Sticks.* — The smaller the diameter of the sticks, the greater the number of pieces per cord and likewise the more air space; therefore, the solid cubic contents are less.

SOLID CUBIC FEET PER STANDARD CORD FOR STICKS OF DIFFERENT DIAMETERS[1]

Diameter of sticks, inches.	Number of sticks per cord.	Hardwoods.	Softwoods.	Mixed hardwood and softwood.
6.80	94	102.40	102.40	102.40
6.00	126	94.72	98.56	96.00
4.75	205	88.32	97.28	92.16
3.50	378	79.36	90.88	84.48

[1] Baur, Franz Adolf Gregor: Untersuchungen über den festgehalt und das gewicht des schichtholzes und der rinde; ausgefuhrt vor dem Vereine deutscher forstliche Versuchsanstatten, Augsburg, 1879.

[1] For a detailed discussion see Factors Influencing the Volume of Wood in the Cord, by Raphael Zon, Forestry Quarterly, Vol. I, pp. 126–133. The tables on pages 115 and 116 are taken from this article.

(3) *Split Wood.* — Split sticks cannot be stacked as closely as round ones, therefore, the solid contents of a cord of the former is less than that of the latter. European practice shows that the solid contents of a cord decreases as the sticks, which are split, increase in length and decrease in diameter. Thus a stack increases in size 6 per cent when sticks from 3.5 to 7 inches in diameter and 21 inches long are split into two pieces; sticks of the same length and a diameter greater than 7 inches show an increase of 4 per cent; 14-inch sticks from 3.5 to 7 inches in diameter show a gain of 5 per cent; and 14-inch sticks of a greater diameter than 7 inches show a gain of 2.5 per cent.

(4) *Form of Sticks.* — Clear boles yield more solid wood per given space than tops and branches because the straighter and smoother the sticks the fewer air spaces there are between them.

SOLID CUBIC FEET PER STANDARD CORD FOR STICKS OF DIFFERENT SIZES[1]

Class.		Number of sticks per cord.	Hardwood.	Softwood.	Mixed hardwood and softwood.
Large	Smooth	104	97.28	96.00	96.00
	Knotty	101	85.76	90.88	88.32
Small	Smooth	162	92.16	92.16	92.16
	Knotty	155	83.20	87.04	84.48

[1] Baur, F. A. G.: loc. cit.

(5) *Degree of Dryness.* — Since green wood shrinks appreciably in volume as it becomes air-dry, the contents of a standard cord of green wood becomes less as seasoning progresses. As a rule, the shrinkage in volume in air-dried wood is from 9 to 14 per cent in hardwoods, and from 9 to 10 per cent in softwoods.

Other factors influencing the solid contents are the methods of piling and fixing the stack, and the methods of measurement used. Practice has shown that stacks in excess of 4.5 feet in height are less carefully piled because of the greater physical effort required to place the wood in the pile. Further, stacks held by one stick on each end contain more solid contents than where the pile is held in place by two or more sticks, since in

the latter case there is less opportunity for crooked sticks to project beyond the edge of the stack. Likewise, the longer the stack the greater the solid contents.

Another factor is the closeness with which the limbs are cut from the sticks, for the rougher the sticks the more air space present.

Stacks are usually somewhat wider at the top than at the base, due to the spread of the supporting sticks. The best practice is to measure the stacks midway between the top and bottom.

Tables showing the volume of solid wood per standard cord for sticks of given lengths and diameters, and also the volume of solid wood in stacks 4 feet high, 8 feet long, and for sticks of given lengths and diameters are given on page 521 in the Appendix.

Cord measure is used chiefly for the measurement of firewood, pulpwood, excelsior wood, stave bolts and like material. In the spruce region of the Northeast pulpwood is often bought in the log by cord measure, without stacking. The contents in cords are determined by calipering the average diameter of the log, determining the length and then reading from a table the number of cubic feet in the stick. The sum of the contents of all logs divided by 128 gives the number of cords. The table on page 522 in the Appendix gives the same results for unpiled logs that would be secured if the wood were piled and measured.

SCALING

The measurement of logs to determine their contents is termed scaling, and men performing the work are called scalers. The scaler's chief tool is a flat or square hickory stick from 3 to 5 feet long which is used to measure diameters. One edge is laid off in inches, and at corresponding points on the two sides and the other edge are shown the contents in board feet of logs of various lengths.

The stick is usually shod with metal on the lower end to enable the scaler to place the rule accurately. The heads are of a variety of patterns; some square, some "T" shaped, and others in the form of a hook from 6 to 12 inches in length. The latter

is serviceable in scaling sniped and rafted logs. Some scale sticks for measuring logs with the bark on have a metal tip only, on the end. When the log has bark on it allowance must be made for the thickness of the latter.

For measuring long logs by the New Hampshire rule a caliper scale stick is used, which is often adjusted so that the scaler need not make allowance for the thickness of the bark.

Scalers are provided with a scale stick; a crayon for marking logs; and a notebook, scale sheets, or a paddle on which are recorded either the contents of each log by lengths, or the length and diameter of each log. In the latter case the volume is calculated in the office.

Scaling practice varies in the different regions according to the log rule used and the purpose for which the measurement is made. In the northern forests the scaling is often done at the skidway or at the landing on the stream before the logs are placed on the rollway.

For skidway scaling a crew of two men is commonly employed. A third man is assigned to the party in case the logs are to be stamped with a log brand. The usual practice is for one man to scale the logs at the small end inside the bark, and the other to record the results. Logs as scaled are marked with a piece of black or blue crayon. When necessary the owner's brand is stamped several times on both ends of the log. The number of the skidway and the number of pieces scaled are sometimes marked on a blazed tree nearby; thus, $\frac{20}{350}$.

In the South scaling is done by one man either at the stump, on the skidways or on the log cars. The usual purpose of the scale in this region is to furnish a basis of payment for contract work and not for the purchase or sale of logs. The latter are marked only with a crayon unless they are to be floated to the mill along with timber of other loggers.

On the Pacific Coast logs may be scaled either on the car, or in the raft when the logs are to be floated to the mill.

The number of logs a scaler can measure daily is exceedingly variable, due to the different conditions under which the work is done. Under favorable conditions, however, he should measure

from 800 to 1000 logs. A scaler and helper in Ontario will average 3000 pieces at a cost of $2\frac{1}{2}$ cents per thousand feet.[1]

The cost of scaling ranges from 2 to 10 cents per thousand feet. Scalers receive from $50 to $100 per month when working on a salary. Contract scaling on large timber ranges from 3 to 5 cents per thousand feet.

It is customary on Government timber sales for a head scaler to check-scale or re-scale a portion of the timber measured by the regular scalers to detect possible errors. The number of pieces re-measured varies from 5 to 25 per cent of the total. The cost of the check-scale is 5 cents or more per thousand feet.

The various steps in the measurement of logs are as follows:

(1) Determination of the length. The scaler may do this by laying off the length with his scale stick, or by measuring with a tape, a pole or a wheel attached to the caliper arm. The wheel has 10 spokes, each armed with a spike, and the spokes are of such length that the distance between each spike is exactly 6 inches. One weighted spoke affords a starting point for measurement. The length of the log is determined from the number of revolutions of the wheel.

Many scalers estimate lengths and measure only occasional logs as a check on short lengths. When log-makers are paid on the basis of the amount of timber cut, this practice often leads to careless work, because a slight shortage in log lengths cannot be detected readily.

(2) Determination of the diameter. Logs of standard length[2] are measured inside the bark at the top or small end. It has become a practice in some regions, particularly in the South, to scale inside the bark on one edge and outside on the other. Custom has made this the recognized method among operators, but it is not standard. The inconsistency of this practice can readily be seen when it is considered that the thickness of bark is not a constant factor even on logs from the same tree and a

[1] See The Canada Lumberman and Woodworker, Toronto, Ontario, Canada, September, 1911, p. 67.

[2] Standard lengths range from 10 to 24 feet inclusive, in multiples of 2 feet.

practical log rule based on the measurement of any portion of the bark could not be devised.

When the log is not round the average diameter is taken. Diameters are usually rounded to even inches, one-half inch or less being tallied as the next even inch below, and over one-half inch, as the next even inch above. Some scalers, however, throw all fractional inches in the next lower inch class.

Veneer logs, especially when they are to be rotary cut, are often measured on the smallest diameter. Extra long logs such as are frequently cut in some parts of the spruce region, the yellow pine region of the South, and the fir region of the Pacific Coast may be scaled as single lengths, with or without allowance for the taper of the log.

On the National Forests, except in Alaska and the territory west of the Cascade Mountains, logs over 16 feet long are scaled as two, and preferably in lengths not less than 12 feet.[1] This is accomplished either by determining the actual diameter of the logs at the intermediate points or by making allowance for the taper. In private practice where no allowance is made for taper, the log rules give results far below the sawing contents of the log.

(3) Determination of the quality or grade of the log. When scaling is done primarily to serve as the basis for the payment of saw or skidding crews it is customary to measure defective logs as though they were sound and to give full credit to the workmen since it requires as much time and labor to fell and handle them as it does sound logs, and discrimination acts as an inducement for workmen to leave defective timber in the woods.

Where the object of scaling is to furnish a basis for the sale of timber it is customary to reduce the scale of defective logs

[1] On the National Forests in Alaska and west of the summit of the Cascade Mountains in Washington and Oregon, logs up to and including 32 feet long are scaled as one log; lengths from 34 to 64 feet, inclusive, are scaled as two logs, the division being made as near the center as possible, for example, a 34-foot log would be scaled as an 18-foot butt log and a 16-foot top log. On logs of average taper the diameter of the larger log may be determined by taking the mean of the top and butt diameters of the whole length by calipering, or by estimating with the aid of a taper table. Greater lengths than 64 feet are scaled as three logs, making the division as nearly equal as possible and in even feet.

and to credit only the amount which the log will actually saw out in merchantable lumber, according to the standard agreed upon between buyer and seller.

The "merchantable timber" may be the basis on which the scaling is done, in which case there is always a chance for argument between buyer and seller. It is better policy to specify that the buyer must take all timber that will produce at least a specified grade of lumber.

Scaling defective logs requires expert judgment and long experience as there are a great variety of defects possible and the determination of the extent to which they influence the sawing contents of the log must be left entirely to the scaler. Rules for discounting unsound logs are of value chiefly as a check on the scaler's judgment. The latter becomes expert through studying defective logs as they are sawed in a mill and actually determining the amount of sawed material that logs with given defects will yield. This varies with the species, character of lumber manufactured, type of saw used, efficiency of the sawyer and the degree of utilization in the manufacturing plant.

Among the defects common to timber are center or heart rot, shake, pin-dote, cat-face, rotten sap, deep checks and seams, crook, crotches, stained sap and rafting pinholes.

Uniform Center or Circular Rot. — There are a number of methods in use for discounting this form of defect.

(1) Assume the scaling diameter of the log to be the diameter minus the diameter of the rotten core. Thus, if a 12-foot log were 20 inches in diameter and the rotten core had a diameter of 6 inches, the scaling diameter would be 14 inches. The loss, using the International rule, would be 125 board feet, or 53 per cent of the total.

(2) Scale the log as sound, compute the contents of the rotten core and subtract this from the gross scale. The loss in the log above cited would be 15 feet, or 7.3 per cent.

(3) Add 3 inches to the diameter of the defect, square the sum and deduct this from the full scale of the log. This method shows a loss of 81 feet, or 34 per cent.

(4)[1] "For uniform defect of 3 inches or less in diameter, deduct 10 feet b.m. in logs up to 16 feet in length.

"For defect 4 to 6 inches in diameter add 3 inches to actual diameter of rot, and deduct from the full scale of the log an amount equal to the contents of a log of the resultant diameter.

"For defect 7 to 12 inches in diameter add 4 inches to diameter of rot and deduct an amount equal to the contents of a log of the resultant diameter from full scale of log.

"In short logs showing defect less than 4 inches in diameter at only one end and not in the knots deduct one-half the amount called for by the rule for the full length of the log.

"In measuring the diameter of this type of rot the scaler should measure it at the end of the log showing the greatest area of defect, since the saw cuts in straight parallel lines."

Using the International scale the above method gives a loss on a 12-foot log, 20 inches in diameter and with a 6-inch rotten core, of 40 feet, or 17 per cent.

The wide variation in the results secured by these different methods shows the weakness of the average systems employed.

In "Forest Mensuration,"[2] certain defects are classified, and tables showing the discounts are given. A cull table for center rot taken from this volume follows. It is based on a study made by Tiemann which established the fact, theoretically, that "in logs of the same length, the loss due to holes of any specified size is practically uniform regardless of the size of the log."

Although the table is designed to be "applicable to all center defects, such as holes, cup shake, rot, etc., which are 4 inches or more from the bark," it is less accurate for holes than for rot.

In actual sawing practice there is a difference in the loss of timber in two logs of a given size, one of which has a rotten core of a certain diameter and the other a hole of the same diameter. When sawing a hollow log enough timber must be left around all sides to hold against the carriage dogs and prevent the saw from

[1] Method used by the U. S. Forest Service.

[2] Forest Mensuration, by Henry Solon Graves. John Wiley and Sons, New York, 1906, p. 71.

breaking down the shell into the cavity. On the other hand, a log with a defective center can be sawed close to the rotten core because the unsound wood prevents the shell from collapsing. The loss on a 6-inch rotten center may be a stick squaring 6 inches by 6 inches in size, while a hole of the same diameter would cause a loss of a square at least 8 inches by 8 inches. With this modification the table can be used with greater safety than many of the rule-of-thumb methods now employed.

In applying the table, the longest diameter of the defect is measured, the loss is then determined from the cull table and subtracted from the gross scale. The defect should be measured at the large end if it runs through the log or appears at the large end only; otherwise, measure at the small end. The table assumes the loss of entire boards even if the defect is visible only at one end.

CULL TABLE

LOSS THROUGH DEFECTS OF DIFFERENT DIAMETERS NEAR THE CENTERS OF LOGS

(Good for defects more than 4 inches from the bark.)

Diameter of defect, inches.	Length of logs in feet.						
	10	12	13	14	16	18	20
	Board feet.						
2	5	6	6.5	7	8	9	10
3	9	11	12	13	15	16.5	18
4	14	17	18	20	23	25.5	28
5	20	24	26	28	32	36	40
6	27.5	33	36	38.5	44	49.5	55
7	36	43	47	50	57	65	72
8	45	54	58.5	63	72	81	90
9	56	67	74	78	89	100	112
10	67	81	87	93	107	120	133
11	80	96	104	112	128	144	160
12	94	113	122	132	151	169.5	188
13	109	131	142	153	175	196.5	218
14	125	150	162.5	175	200	225	250
15	142	171	184	218	226	255	283

Circular Shake. — This may be discounted in the same manner as circular rot, by determining the diameter of the defect outside of the shake "rings." When there is a solid core inside of the

shake rings the contents are subtracted from the gross scale of the defect and the remainder deducted from the full scale of the log.

Pin-dote. — This defect appears on the ends of logs as small rotten spots, often distributed in a circular form. The rot frequently starts from punk knots and near the latter the log may be very defective. When the visible area affected is 4 inches or more in diameter the usual method is to discount the log contents in the same manner as for circular rot.

Stump or Butt Rot. — This defect seldom extends more than a few feet into the log and usually tapers to a point. Where the wood is only slightly rotten and the affected area is small, the defect seldom extends more than a few inches and often no allowance is made for it.

When the defect occupies the center of the log and extends nearly to the bark, the usual practice is to reduce the scaling length. When a few boards can be cut from the outer shell of the affected portion their board-foot contents are added to the merchantable scale.

Butt rot near one edge of the log may be largely removed by the slab, and the scaler must exercise judgment in determining the deduction to be made.

Cat-face. — This may be due to an injury to the butt by fire, or to wounds made by split shingle makers who cut into trees to determine the straightness of the grain of the wood. The common practice is to divide the log into sections, then determine what proportion of a particular section will be lost in manufacture and deduct this amount.

Other Side Defects. — Lightning scars seldom extend far into the wood and are usually removed with the slab. Unless deep they are disregarded.

Punk knots which are an indication of red heart or rot often render a log practically worthless, especially when rot appears at either end. As a rule, pine timber that is badly affected has exudations of resin at numerous points along the bole and often bears fruiting bodies of a fungus. The scaler's judgment is the only guide in discounting logs of this character.

Rotten Sap. — The sound heartwood only is measured on logs having this defect.

Stained Sap. — Sound stained sapwood of most species is merchantable if it has not been attacked by wood-boring insects. The full scale is given for sound material, but when the sapwood is worm-eaten the heartwood only is measured.

Checks and Seams. — These are found chiefly on dead timber from which the bark has fallen. They usually extend through the sap, and on timber that has been dead for some years they may extend well toward the center of the tree. Where the checks are small the scaling diameter is taken inside the sap, while on logs with wide checks a further deduction must be made in accordance with the scaler's judgment.

A single deep check can usually be sawed out by the loss of one or two boards and their contents only should be deducted.

Spiral Checks. — Where deep spiral checks occur the scaling diameter is that of the largest circle that can be secured without the inclusion of the checks.

Crook or Sweep. — The percentage of loss from this defect is greater on small logs than on large ones. The contents of the log may be determined by finding where the saws will square the log sufficiently to enable boards of the narrowest merchantable width to be cut. If the sweep is pronounced, a few short boards may be secured from the slab, in which case their estimated board-foot contents are added to the scale of the log.

Crotches. — Logs with crotches near the end are reduced in length sufficiently to eliminate the crotch. The scaling diameter is taken just below the enlargement caused by the fork.

Rafting Pinholes. — These are usually about 2 inches in diameter and located near the ends of the log. They can generally be removed by wasting the ends, or portions of a few boards, provided the log is sawed in an economical manner. The only guide to discounting defects of this character is the scaler's judgment.

LOG GRADES

Logs that are brought into large markets for sale are classified into grades that have been adopted by associations. Printed

rules for the guidance of inspectors have been issued. The specifications contained in them furnish the basis on which market quotations are made. Grades are enforced by scalers employed by the associations and a fee is charged for their services.

Among the chief hardwood log-grading rules are those of the Lumbermen's Association, Nashville, Tennessee, and among the chief softwood rules are those of the Columbia River Log Scaling and Grading Bureau, Portland, Oregon, copies of which are given on pages 525 to 528, inclusive, in the Appendix.

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PART III

LAND TRANSPORT

CHAPTER IX

ANIMAL DRAFT POWER

For many years animals constituted the only draft power used in logging operations in the United States. They are still used extensively in the spruce region of the Northeast, the Appalachians, the yellow pine forests of the South, the Lake States, the Inland Empire and portions of California. In all of these regions machinery has replaced them for some purposes, yet animal logging is still the chief method.

Animals are now seldom employed for moving heavy timber, for swamp logging or for work on very rough ground and very steep slopes. Power-driven machinery has supplanted them in the redwood belt of California, the fir forests of the Northwest, the cypress swamps of the South and some of the rough mountainous portions of the United States.

They still remain the favorite form of draft where the timber is of medium size, where the stand per acre is less than 5000 feet and where topography and bottom afford good footing.

The chief uses for animals in logging are to transport timber and other forest products from the stump to a collecting point along a logging railroad, a landing on some stream or to a sawmill. In addition they often supply the power for decking logs on skidways, and loading logs on sleds, wagons and logging cars. Even where machinery is used for skidding logs, animals may be required to return the cable to the woods and to haul wood and water for the engines.

Oxen. — Oxen were the only animals owned by many of the pioneer lumbermen and, even after horses were available, loggers operating in remote sections found the ox more desirable because it could live on coarser feed, draw heavier loads, stand rougher treatment and required an inexpensive harness which could be made in camp.

Conditions have changed within recent years, and the higher cost of labor and supplies has led the logger to use either horses or mules because they are more active than oxen. Oxen are now most extensively employed in the hardwood regions of the Appalachians and in the yellow pine region of the South, where they are frequently supplemented by horses or mules.

The following conditions are those under which oxen may be used to the best advantage:

(1) On swampy ground, because they do not mire as badly as the smaller-footed horse or mule.

(2) For skidding on brushy ground, as they require little swamping.

(3) On steep slopes, especially if the ground is rough and the underbrush abundant, because they are not excitable in difficult situations.

One advantage is that eight or ten animals can be handled by one teamster, while only four or five horses or mules can be worked by one man. Oxen stand heavy pulling day after day better than other draft animals and also require a minimum of attention because only one feed per day is necessary if the animals are turned out to graze at night.

They are slow on short hauls but they can be loaded more heavily and thus partially offset the greater speed of horses and mules, although they are not as serviceable as mules on hot, dusty roads because they suffer from continual exposure to the direct rays of the sun, and, on very warm days, may be easily killed by over-exertion due to careless driving. They can be used in cold regions without danger. Under average conditions an ox will travel fourteen miles in eight hours.

Oxen are usually harnessed with a yoke; seldom with a collar and harness. The driver controls them by the voice and by a heavy rawhide whip. They are worked in teams of from three to five yoke. In a team of five yoke the front pair are called "leaders," the next two pairs are "in the swing," the fourth pair are "point cattle" and the rear pair are called "wheelers." The leaders are the best trained, while the wheelers are the heaviest yoke of the team.

The training begins when the animals reach the age of one and one-half or two years, but they do not attain their best development until their fifth or sixth year. They are serviceable, under average conditions, until they reach the age of ten or twelve years.

In the South oxen for logging purposes weigh about 1200 pounds and are generally purchased from farmers near the logging operation. They cost from $60 to $100 per yoke for average animals and because of insufficient food are usually light weight when purchased and require a year or more of proper feeding before they attain their average efficiency. Heavy or well-trained animals may bring as high as $200 per yoke.

Horses. — Horses are commonly used in the Appalachians, Lake States, Inland Empire and the Northeast. They stand cold weather well, are active and are moderate eaters. They are best adapted for logging on smooth or rolling ground, and with good care will remain efficient for from four to seven years. In northern Alabama, when well cared for, they are as satisfactory as mules, but farther south the climate is not favorable for them. When improperly housed and fed they are less efficient under similar conditions than mules or oxen.

Horses weighing from 1200 to 1400 pounds are best adapted for handling small logs and for rough work in the Northeast. For heavy logging and two-sled hauling horses weighing from 1500 to 1800 pounds are preferred. Animals of this weight are not adapted to rough ground or steep slopes because they are not active enough. They are also too heavy for use on frozen slopes with a grade exceeding 25 degrees.

Horses for logging purposes are generally purchased from dealers who make a specialty of draft animals. Good animals for logging work are worth about $250 each.

Mules. — Mules are used more extensively in the South than in any other section.

The chief points of advantage are:

(1) They will stand more heat than an ox or a horse and are, therefore, better adapted for long or hard hauls during summer months or in a hot climate.

(2) They will stand rougher treatment and perform more labor on poor feed than a horse.

(3) They are less excitable than horses and, therefore, are well suited for use in operations where colored teamsters are employed.

(4) They are more agile than horses on rough ground.

(5) They eat less than horses and seldom overfeed. Mules have not proved a success in the North where low temperatures prevail during the winter.

Under favorable conditions there is little difference in the amount of work performed daily by mules and horses.

Mules for logging purposes range in weight from 1100 pounds for leaders to 1300 pounds for wheelers. They cost from $225 to $250 each in the St. Louis, Kansas City and other mule markets. Southern loggers usually purchase their mules at one of the two markets mentioned or from farmers in Kansas and nearby states. The best mules are raised in Missouri, Kentucky and Kansas.

RATIONS

The rations given to animals vary greatly because of the difference in the character of feed available and the diversified opinions of feeders.

A draft animal at hard work requires a certain amount of concentrated food containing protein, carbohydrates and fats, which is fed in the form of grains, such as corn, oats and barley; mill products, including corn meal, ground corn and oats, and similar combinations; and the by-products, cottonseed meal, cottonseed hulls and linseed meal. In addition, animals require rough material, such as hay of various kinds, corn fodder, corn husks and like feeds to give bulk to the ration. If no rough fodder or hay is given, an animal will consume more concentrated food than necessary to keep it in working condition. On the other hand, heavily-worked animals cannot subsist on roughage alone because the digestible nutrients are so small that they cannot consume a sufficient bulk to secure the proper amount of nourishment.

In preparing rations for animals, horses and mules require

different treatment from oxen because they have smaller stomachs. As they have less power to digest foods, they must be fed less at one time and at more frequent intervals.

The degree of digestibility is dependent on two factors; namely, the length of time the food remains in the digestive tract,[1] and on the fineness of the division of the food. Mastication is less in horses and mules than in oxen because the former must do all the chewing before the food is swallowed while ruminants, such as the ox, regurgitate their food and chew it at will.

German students of animal nutrition, among them Wolff and Lehmann, have prepared tables showing the amount of chemical constituents required for animals of a standard weight of 1000 pounds, performing a given kind of labor. Other weights are in proportion. These tables are known as feeding standards and are an approximate statement of the amounts of the different nutrients required by animals. They serve as a guide for feeders.

WOLFF-LEHMANN FEEDING STANDARDS[1]

[Showing amounts of nutrients per 1000 pounds live weight for one day's feeding.]

Animal.	Total dry matter.	Digestible nutrients.			Fuel[3] value.
		Protein.	Carbohydrates.	Fat.	
	Pounds.	Pounds.	Pounds.	Pounds.	Calories.[4]
Oxen:[2]					
At rest in stall	18	0.7	8.0	0.1	16,600
At light work	22	1.4	10.0	0.3	22,500
At medium work	25	2.0	11.5	0.5	27,200
At heavy work	28	2.8	13.0	0.8	32,755
Horses:					
At light work	20	1.5	9.5	0.4	22,150
At medium work	24	2.0	11.0	0.6	26,700
At heavy work	26	2.5	13.3	0.8	32,750

[1] From The Feeding of Farm Animals, by E. W. Allen. Farmers' Bulletin No. 22, U. S. Department of Agriculture, Washington, D. C., 1901, p. 12.

[2] For an unworked ox of 1000 pounds weight the standard calls for 0.78 pound of digestible protein, 8 pounds of digestible carbohydrates, and 0.1 pound of digestible fat, which would furnish 16,600 calories of heat and energy. When heavily worked the same ox would require, according to the standard, food with four times as much protein and of nearly twice the fuel value.

[3] The value of food to produce heat for the body and energy for work is measured in calories and is calculated from the nutrients digested. The fuel value of one pound of digestible fat is estimated to be 4230 calories and of one pound of digestible protein or of carbohydrates about 1860 calories. The total value of a feeding stuff is found by using these factors, the equivalents for the common foods being given on pages 134 and 135.

[4] A calorie is the amount of heat required to raise the temperature of one pound of water about 4 degrees.

[1] Cattle are said to retain their food from three to eight days, while horses retain it four days or less.

If overfeeding is detected by loggers a new ration may be calculated, or the present ration modified with the aid of this feeding standard and the following table which shows the amount of digestible food ingredients in the common feeding stuffs.

DRY MATTER AND DIGESTIBLE FOOD INGREDIENTS IN 100 POUNDS OF FEEDING STUFFS[1]

Feeding stuff.	Total dry matter.	Protein.	Carbohydrates.	Fat.	Fuel value.
Green fodder:	Pounds.	Pounds.	Pounds.	Pounds.	Calories.
Corn fodder (average of all varieties)	20.7	1.10	12.08	0.37	26,076
Kafir-corn fodder	27.0	0.87	13.80	0.43	29,101
Rye fodder	23.4	2.05	14.11	0.44	31,914
Oat fodder	37.8	2.44	17.99	0.97	42,093
Redtop, in bloom	34.7	2.06	21.24	0.58	45,785
Orchard grass, in bloom	27.0	1.91	15.91	0.58	35,593
Meadow fescue, in bloom	30.1	1.49	16.78	0.42	35,755
Timothy, at different stages	38.4	2.01	21.22	0.64	45,909
Kentucky blue grass	34.9	2.66	17.78	0.69	40,930
Hungarian grass	28.9	1.92	15.63	0.36	34,162
Red clover, at different stages	29.2	3.07	14.82	0.69	36,187
Crimson clover	19.3	2.16	9.31	0.44	23,191
Alfalfa, at different stages	28.2	3.89	11.20	0.41	29,798
Cowpea	16.4	1.68	8.08	0.25	19,209
Soy bean	28.5	2.79	11.82	0.63	29,833
Rape	14.3	2.16	8.65	0.32	21,457
Corn silage (recent analyses)	25.6	1.21	14.56	0.88	33,046
Corn fodder, field cured	57.8	2.34	32.34	1.15	69,358
Corn stover, field cured	59.5	1.98	33.16	0.57	67,766
Hay from —					
Barley	89.4	5.11	35.94	1.55	82,894
Oats	84.0	4.07	33.35	1.67	76,649
Orchard grass	90.1	4.78	41.99	1.40	92,900
Redtop	91.1	4.82	46.83	0.95	100,078
Timothy (all analyses)	86.8	2.89	43.72	1.43	92,729
Kentucky blue grass	78.8	4.76	37.46	1.99	86,927
Hungarian grass	92.3	4.50	51.67	1.34	110,131
Meadow fescue	80.0	4.20	43.34	1.73	95,725
Mixed grasses	87.1	4.22	43.26	1.33	93,925
Mixed grasses and clover	87.1	6.16	42.71	1.46	97,059
Red clover	84.7	7.38	38.15	1.81	92,324
Alsike clover	90.3	8.15	41.70	1.36	98,460
White clover	90.3	11.46	41.82	1.48	105,346
Crimson clover	91.4	10.49	38.13	1.29	95,877
Alfalfa	91.6	10.58	37.33	1.38	94,936
Cowpea	89.3	10.79	38.40	1.51	97,865
Soy bean	88.7	10.78	38.72	1.54	98,569
Wheat straw	90.4	0.37	36.30	0.40	69,894
Rye straw	92.9	0.63	40.58	0.38	78,254
Oat straw	90.8	1.20	38.64	0.76	77,310
Soy-bean straw	89.9	2.30	39.98	1.03	82,987
Roots and tubers:					
Mangel-wurzels	9.1	1.03	5.65	0.11	12,889
Turnips	9.5	0.81	6.46	0.11	13,986

[1] From The Feeding of Farm Animals, by E. W. Allen. Farmers' Bulletin No. 22, U. S. Department of Agriculture, Washington, D. C., 1901, p. 8.

DRY MATTER AND DIGESTIBLE FOOD INGREDIENTS IN 100 POUNDS OF FEEDING STUFFS[1] (*Continued*)

Feeding stuff.	Total dry matter.	Protein.	Carbohydrates.	Fat.	Fuel value.
	Pounds.	Pounds.	Pounds.	Pounds.	Calories.
Roots and Tubers:					
Ruta-bagas	11.4	0.88	7.74	0.11	16,497
Carrots	11.4	0.81	7.83	0.22	16,999
Grains and other seeds:					
Corn (average of dent and flint)	81.1	7.14	66.12	4.97	157,237
Kafir corn	87.5	5.78	53.58	1.33	116,022
Barley	89.1	8.69	64.83	1.60	143,499
Oats	89.0	9.25	48.34	4.18	124,757
Rye	88.4	9.12	69.73	1.36	152,400
Wheat (all varieties)	89.5	10.23	69.21	1.68	154,848
Cottonseed (whole)	89.7	11.08	33.13	18.44	160,047
Mill products:					
Corn meal	85.0	6.26	65.26	3.50	147,797
Corn-and-cob meal	84.9	4.76	60.06	2.94	132,972
Barley meal	88.1	7.36	62.88	1.96	138,918
Ground corn and oats, equal parts	88.1	7.01	61.20	3.87	143,202
Pea meal	89.5	16.77	51.78	0.65	130,246
Waste products:					
Rye bran	88.2	11.47	52.40	1.79	126,352
Wheat bran, all analyses	88.5	12.01	41.23	2.87	111,138
Wheat middlings	84.0	12.79	53.15	3.40	136,996
Wheat shorts	88.2	12.22	49.98	3.83	131,855
Buckwheat bran	88.5	19.29	31.65	4.56	113,992
Buckwheat middlings	88.2	22.34	36.14	6.21	134,979
Cottonseed feed	92.0	9.65	38.57	3.37	103,911
Cottonseed meal	91.8	37.01	16.52	12.58	152,653
Cottonseed hulls	88.9	1.05	32.21	1.89	69,839
Linseed meal (old process)	90.8	28.76	32.81	7.06	144,313
Linseed meal (new process)	90.1	30.59	38.72	2.90	141,155

[1] From The Feeding of Farm Animals, by E. W. Allen. Farmers' Bulletin No. 22, U. S. Department of Agriculture, Washington, D.C., 1901, p. 8.

In calculating rations according to the preceding tables, it is only essential that the quantities of carbohydrates and fats correspond approximately, because they both serve practically the same purpose and an excess of one may be offset by a deficiency of the other.

The test of the fitness of a ration for a draft animal is the ability of the animal to maintain an even weight. Generally, if a healthy animal loses weight, it is an indication of insufficient food, while an increase denotes an excessive ration. This does not refer to minor changes in weight from day to day but to changes observed over a period of several weeks.

RATIONS ACTUALLY FED TO HORSES AND DIGESTIBLE NUTRIENTS AND ENERGY IN RATIONS CALCULATED TO A BASIS OF 1000 POUNDS LIVE WEIGHT[1]

Kind of animals.	Weight of horses.	Rations actually fed.	Nutrients in ration per 1000 pounds live weight.				Digestible nutrients in rations per 1000 pounds live weight.				Energy in digestible nutrients.
			Protein.	Fat.	Nitrogen-free extract.	Crude fiber.	Protein.	Fat.	Nitrogen-free extract.	Crude fiber.	
	Lbs	Lbs	Lbs	Lbs	Lbs	Lbs	Lbs	Lbs	Lbs	Lbs	Calories.
Army horses.[2]											
United States:											
Cavalry	1050	Oats, 12; Hay, 14	2.14	0.90	12.82	4.95	1.25	0.57	8.00	1.97	23,300
Artillery	1125	Oats, 12; Hay, 14	2.00	0.84	11.96	4.62	1.16	0.53	7.48	1.84	21,750
Mules	1025	Oats, 9; Hay, 14	1.84	0.78	11.39	4.80	1.00	0.48	6.88	1.94	20,250
Farm horses.											
General average for moderate work.	....	....	2.38	0.77	11.99	4.08	1.49	0.42	8.09	1.63	22,710
Farm mules, Virginia Station.	1310	Hay, 15.2; Corn, 10.5; Corn silage, 10.5	1.70	0.82	12.00	4.00	0.72	0.42	8.22	1.75	21,655
Average of 6, including above.	....	....	1.64	0.78	11.54	3.74	0.69	0.39	7.95	1.60	20,675
Horses with severe work.											
Truck and draft horses:											
Chicago, Ill., daily ration.	1500	Oats, 7.5; Hay, 20	1.38	0.58	8.99	4.34	0.64	0.34	5.11	1.79	15,450
South Omaha, Neb.	1500	Oats, 15; Hay, 12	1.65	0.70	9.57	3.27	1.04	0.45	6.23	1.27	17,800
Average of 5, including above.	....	....	1.80	0.76	10.49	3.49	1.12	0.49	6.94	1.35	19,560
Feeding standards and average rations.											
American experiments.											
Horses with light work:											
Driving horses	....	....	......	....	......	....	1.58	0.22	5.27	1.18	15,895
General average	....	....	......	....	......	....	0.99	0.32	5.06	1.24	14,890
Horses with moderate work:											
Express and cab horses	....	....	......	....	......	....	1.06	0.49	7.33	1.72	20,860
Farm horses	....	....	......	....	......	....	1.57	0.40	8.09	1.62	22,760
General average	....	....	......	....	......	....	1.49	0.42	8.09	1.63	22,710
Mules with moderate work: Farm mules.	....	....	......	....	......	....	0.69	0.39	7.95	1.60	20,675
Horses with severe work: Truck and draft horses.	....	....	......	....	......	....	1.12	0.49	6.94	1.35	19,560

[1] From Principles of Horse Feeding, by C. F. Langworthy. Farmers' Bulletin No. 170, U. S. Department of Agriculture, Washington, D. C., 1903, p. 31.

[2] The standard salt allowance is 2 ounces weekly.

RATIONS FED BY LOGGERS

Horses:		
Heavy work at a sawmill, Canada.	15 pounds hay. 10 pounds ground grain. 1 pound bran. 8 pounds oats.	Barley } Oats } 1 to 1.
Maine logging operation.	$10\frac{1}{2}$ pounds corn. 12 pounds oats. 40 pounds hay.	Animals weighing about 1600 pounds each.
Mules:		
Louisiana logging operation.	$13\frac{1}{2}$ pounds corn-alfalfa. 55 pounds chops. 16 pounds hay.	Animals weighing about 1300 pounds each.
Missouri logging operation.	8 pounds oats. 7 pounds corn. 40 pounds hay.	Animals weighing from 1200 to 1300 pounds each.
Oxen:		
Mississippi logging operation.	20 pounds cottonseed hulls. 5 pounds cottonseed meal. 10 pounds hay.	
Alabama logging operation.	21 pounds corn. Corn fodder (unlimited).	
Louisiana logging operation.	26 pounds corn. 14 pounds hay.	

WEIGHT OF FEEDING STUFFS PER QUART[1]

Feeding stuff.	Pound.	Ounces.
Corn, cracked	1	12
Corn meal	1	8
Corn-and-cob meal	1	6
Oats, whole	1	...
Oats, ground	..	12
Wheat, whole	1	14
Wheat bran	...	10
Wheat bran, coarse	...	8
Wheat middlings	1	2
Wheat middlings, coarse	...	13
Rye bran	...	10
Gluten meal	1	11
Gluten feed	1	3
Linseed meal	1	2
Cottonseed meal	1	8

[1] From The Feeding of Farm Animals, by E. W. Allen. Farmers' Bulletin No. 22, U. S. Department of Agriculture, Washington, D. C., 1901, p. 19.

A record of the rations fed to horses and mules performing various classes of labor has been collected and published. A portion of a table is given on page 136 followed on page 137 by some rations fed in the lumber regions. The weight of animals to which the latter refers is not known definitely and a close comparison cannot be made. They are of interest, however, because they show variation from the feeds given in the table.

Some of these materials, especially by-products like wheat bran, vary considerably in weight, and the above figures cannot be regarded as strictly accurate for all cases. Weighing is, of course, always the safer way where it is desired to feed definite amounts.

WATER REQUIREMENTS

The amount of water required by horses depends largely upon the season of the year, the temperature of the air, the character of the feed, the individual peculiarities of the horse and the amount and character of the work performed. The water requirements increase with a rise in temperature and with the amount of work performed since both factors induce perspiration.

Less water is required when concentrated or green succulent foods are fed than when the bulk of the ration consists of coarse fodder or of dry food. A horse under average conditions will drink from fifty to sixty-five pounds of water daily, while under heavy work or during warm weather from 85 to 110 pounds will be consumed. Mules in Oklahoma, during hot summer weather, consumed 113 pounds of water daily with a minimum of 107 pounds and a maximum of 175.[1] The ration was composed of grain and hay.

Experiments conducted in the British Army showed that horses, when allowed to drink at will, consumed about one-fourth of their daily allowance in the morning, about three-eighths at noon and the remainder at night.

[1] See Principles of Horse Feeding, by C. F. Langworthy. Farmers' Bulletin, No. 170, U. S. Department of Agriculture.

European experiments demonstrated that the time of drinking has no appreciable effect on the digestibility of the food. Animals may be watered either before or after feeding with equally good results, but it is desirable to always observe the same practice since some animals do not feed well if watered after feeding, when they are accustomed to being watered before.

CHAPTER X

SKIDWAYS AND STORAGE SITES

The transport of timber from the stump to the manufacturing plant generally comprises two distinct operations.[1]

(1) Assembling the logs at depots, called skidways or yards, usually near the point of felling. This is termed skidding or yarding, and may be accomplished by manual labor; by animal power with or without the use of vehicles; by power-driven machinery; or by log slides and chutes.

(2) The transport of the assembled logs to a stream or to the manufacturing plant. This is termed hauling and is most frequently done with some form of cart, wagon, sled, railroad or log slide.

Skidding and hauling may be conducted simultaneously, as in the South and West where rail transport is used, or at different seasons, as in the spruce forests of New England where hauling is done on sleds.

LOG STORAGE IN THE FOREST

The character and location of the storage points depend on the manner in which the timber is to be hauled and on the topography.

For Sled Haul. — Where sleds are used the skidway consists of a skeleton log structure built crib-fashion, and so placed that the logs can be stored parallel with the road. That portion of the structure nearest the road should be at least as high, and when practicable, higher than the sled bunks, so that a portion of the load can be put on by hand. The rear end is placed on a level with the ground in order that logs can be rolled on the bed skids without difficulty.

[1] On small operations the logs may be taken direct from the stump to the mill.

Logs are decked on level ground to a height of from 20 to 30 feet. They are elevated by means of the crosshaul, operated by animals. A "decking" crew is made up of four or five men and one team. The equipment comprises four cant hooks, two pole skids 6 inches in diameter and from 8 to 10 feet long, and a $\frac{3}{8}$-inch crosshaul chain about 40 feet long with a grab hook on one end.

The logs are brought to the rear of the skidway and are then rolled by a "tailer-in" to the base of the logs already decked. The end of the chain carrying the hook is then thrown over and under the center of the log to be decked, after which the hook is fastened to one of the decked logs just below the spot where it is desired to place the new log. The free end of the chain passes over the skidway and, if the pull is to be straight away, is attached to a hook on the double-tree.

After adjusting the chain, skids are placed against the decked logs, and the team is started. Two "ground loaders" guide the log straight up the skids using cant hooks for this purpose. Logs with taper, crooks, large knots and similar defects seldom roll straight and the ground loaders must be on their guard continually. A "top-loader" who stands on top of the pile of logs directs the log to its place, frees the grab hook if necessary and also directs the teamster. The direction of pull may be modified to meet special conditions. For instance, instead of attaching the chain directly to the double-tree it may be passed through a block fastened to a tree directly behind the skidway. This enables the team to pull at right angles to the direction in which the log is traveling and is of especial advantage when brush, boggy ground or other obstacles prevent a straight-away pull. The chain may also be passed through a block and brought forward over the skidway so that the horses pull on the same side on which the logs are being decked. This may be desirable where there is a bad bottom or some other physical hindrance to the usual method of operating.

Large skidways can be filled most economically when they are built in tiers on slopes. The logs are then delivered above the skidway and rolled to the levels below. Large side-

hill skidways may contain from 100,000 to 500,000 feet log scale.

During hauling time skidways may be places of transfer from skidding to hauling equipment in which event they are known as "hot skidways."

When sleds are used for hauling, the skidways are located at convenient points along the logging roads which lead down to a landing or second large storage yard on a stream down which the

FIG. 26. — Skidways along a Two-sled Road. Montana.

logs are to be floated. The sites for skidways should be selected by the logging foreman at the time the sled roads are laid out, and the routes of the latter should be chosen with reference to good skidway sites as well as desirable grades. Provision should be made for a down-hill haul from the stump to the storage point. Skidding cannot be carried on profitably for long distances on level ground, consequently a flat country requires the greatest number of skidways. Large skidways are preferable because there is less snow to be shoveled off at loading time, and the

construction and maintenance of a minimum mileage of road is required.

Landings. — Temporary storage grounds, called "landings," are made along the banks of driveable streams or on the edge of lakes where logs are to be transported by water. Their form depends on the character of the stream down which the logs are to be driven. Where the stream is small and the storage area limited, the logs are hand-decked from 15 to 30 feet high, in the stream bed, parallel to the banks. When a large volume of flood water is available in the spring, the logs may be dumped promiscuously into the stream and the floods relied upon to carry them out.

Logs placed on frozen streams or lakes are scattered over a wide area in order to save the labor of decking and to prevent the weight of the logs from breaking through the ice.

For Wagon Haul. — Skidways are seldom made for wagon hauling. The logs are bunched in the forest in a place accessible to the wagons and are loaded with the crosshaul and taken to a skidway along the railroad or direct to the mill.

For Railroad Haul. — These vary in character depending on whether the logs are loaded on cars by animals or by power.

Skidway sites for animal loading with the crosshaul should not be lower than the track because it is too difficult to handle the logs. A straight "get-away" of 40 feet should be provided on the side of the track opposite the skidway where the loading team can travel back and forth.

An area several hundred feet in length along the track may be cleared for storage especially if the stand of timber is heavy and hauling precedes rail transport by some weeks in which case the skidway can then be used but once. Where hauling is simultaneous with rail transport, skidways are filled repeatedly and less storage space is required.

With animal loading it is essential that the logs be carefully piled parallel to the railroad track. The skidways consist of two continuous rows of poles placed about 8 feet apart and extending at right angles to the track for a maximum distance of 100 feet. The logs are brought to the rear of the skidway and

rolled toward the track, leaving a clearance of approximately 10 feet between the first log and the rail. Logs are seldom decked more than four high as it is more economical to place new skids than to spend time in decking.

Where power loaders are used, skidways are often merely areas along the track from which the brush and débris have been removed so that the teams can deliver the logs. In a flat region where plenty of space is available the logs are seldom decked. It is unnecessary to have logs arranged parallel to the track or placed on skids since the loader can pick them up readily at distances not to exceed 100 feet. If there are steep slopes near the railroad, logs are often hauled to the edge and rolled down by gravity, forming a "rough and tumble" skidway. This provides a large storage area and reduces labor in handling the logs. Since power loaders can readily pick up logs several feet below the level of the track the logger can locate his railroad without reference to loading sites. See Fig. 78.

CHAPTER XI

HAND LOGGING AND ANIMAL SNAKING

HAND LOGGING

The movement of logs by hand from the stump to a point where they can be reached by animals is commonly practiced in the mountainous region of the Appalachians and is known as "brutting." Trails are cleared down the steep slopes and the logs are rolled to a stream bed or flat where hand labor is replaced by animal labor. Hewed crossties are frequently made in rough mountain regions and dragged down the slopes to streams or to accessible points.

Hand logging is also practiced in the white cedar (*Chamæcyparis thyoides*) forests of the Coastal Plain region. The trees are felled, cut into sections and carried by men or carted on wheelbarrows over plank runs to a light tram road where they are loaded on small cars and pushed to a point available to a stream tram road.

Some operators in the cypress swamps of this region cut swaths, called "creeks," at half-mile intervals through the forests locating them with reference to the current when the swamp is flooded. These are made during a dry season and are cut from 50 to 150 feet wide according to the number of logs that are to be floated down them. The trees which have been girdled for about a year are felled and cut into logs during a dry period and left on the ground until flood waters cover the swamp to a depth of 5 or 6 feet. Negro laborers are then taken to the swamp in boats and they pole the logs, sometimes for a quarter of a mile, to the nearest "creek" down which they are floated to the rafting ground, where they are made into rafts, and then towed to a mill.

Hand logging was common on the Pacific Coast for many years before the industry reached its present development. The

timber was felled on slopes close to tidewater or some driveable stream, the logs were rolled into the water, made into rafts and sold to large loggers or manufacturers who transported them to market. Often the stumpage was not the property of the logger who cut it and the timber was sold at a price slightly above the cost of the labor expended upon it. The increase in the value of stumpage and the greater care given to timber properties by the owners has largely eliminated this class of loggers in the United States. In British Columbia hand logging is still practiced to a limited extent by virtue of "hand logger's" permits issued by the Provincial Government.

The introduction of modern machinery for logging has given a wider meaning to the term hand logging on the Coast, and it is now applied to loggers who operate on a small scale with animals.

SNAKING WITH ANIMALS

The transportation of logs with animals without the use of vehicles is practiced in many parts of the country either to take logs from the stump to a skidway or to transport them for longer distances to a stream, railroad, chute or other form of long-distance transport.

The first is usually a short-distance method and the logs are taken out over crude trails from which only such obstructions have been removed as are necessary to make snaking feasible. The usual distance for snaking on level or gentle slopes does not exceed 500 feet. However, logs may be brought from the stump to skidways 1000 or 1200 feet distant, but such long distances are not considered advisable except where there is a downgrade, or where there is not enough timber to warrant the construction of a road nearer to it.

Animals for skidding may be used singly or in teams when horses or mules are employed, or in single, double or triple yokes when oxen are used. The number of animals is governed by the weight of the timber handled, the character of bottom and the grade of the skidding trail.

In the spruce region of the Northeast, two animals are used

FIG. 27. — Skidding Trails leading down to a Skidway along the Logging Railroad. West Virginia.

FIG. 28. — Oxen skidding a Yellow Pine Log containing 1200 Feet. Arkansas.

to yard timber, because logs are cut in long lengths, while in northern New York single animals are usually employed because the timber is cut in short lengths. The usual practice in other regions is to use two or more animals.

Single animals have been tried for skidding small second-growth loblolly pine in the Coastal Plain Region, but because of the heaviness of the wood and the enervating climate they have not proved satisfactory.

Fig. 29. — A Skipper Road on a West Virginia Operation.

The second method is common in the rough sections of the Appalachians and Pennsylvania, where horses are used for snaking logs for distances not exceeding one mile. The logs are brought down trails which are sometimes so steep that the animals must be returned to the woods by a more circuitous route. A trail is made 6 or 8 feet wide, cleared of obstructions and banked on the outer edge with skids to prevent logs from leaving them. Swamps are corduroyed, streams bridged and rough places covered with "skippers." These are timbers 8 or 10 inches in diameter and 12 feet long which are either placed zig-

zag across the road, the angle between skippers being about 60 degrees, or the poles are placed directly across the trail at intervals of from 4 to 6 feet. Logs often drag over zigzag skippers more smoothly than over those placed directly across the trail. Rough chutes are sometimes built in the stream beds to cover rocks and other obstructions, when it is necessary to divert the trail from the slopes to the stream bed. Short-radius curves are undesirable because they decrease the draft power of the animals, and make it hard to keep a long turn of logs in the trail. Logs are brought down in "turns" made up of several logs fastened in single file. On level stretches a two-pole chute is sometimes built to facilitate dragging (page 233). They are occasionally used on gentle slopes if the bottom is rough.

On the Pacific Coast long-distance snaking has been replaced largely by road engines and railroads, because animal draft is more expensive than either of the above systems for distances of three-fourths of a mile or more. Animals are still used to a limited extent however, for short hauls on small operations. Skid roads built for animal snaking in the Northwest are carefully located, stumps are removed, cuts and fills made and the roadbed leveled so that a desirable grade is secured. Skids 10 feet long and from 10 to 14 inches in diameter are laid across the completed grade at 10-foot intervals, and are partly buried in the ground so that the horses can step over them easily. Wet places in the roadbed are covered with puncheons split from western red cedar, to provide a footing for animals. A "saddle" is adzed out of the center of each skid and in this the log rides. On curves the skids are longer and are either elevated on the inner side of the curve to prevent the tow of logs from crowding into the bank or the skids are laid flat and the elevation is secured by placing small sloping skids on the inside of the curve. The latter is regarded as the better method since the small skids can be more easily placed and, if necessary, the angle of inclination can be readily changed. On level stretches the saddles are greased to reduce friction. Logs are fastened together by means of "grabs" into long tows, each one averaging 1000 board feet per horse. A team on a road of this character formerly consisted

of from eight to ten yoke of oxen but they have been replaced by horses, from four to fourteen constituting one team.

Drumming. — A primitive form of skidding, called "drumming," is employed by small operators in the mountain regions of the Appalachians where the slopes are too steep for animal skidding, too rough for cheap road construction, and where the size of the operation does not warrant the use of power-driven machinery.

The equipment consists of a large drum, hung on a vertical axis, placed close to the edge of the plateau. Fastened to the barrel of the drum is a long horizontal lever arm to which a pair of mules are hitched. A short stout pole is fastened by one end to this lever arm and the other end drags on the ground in the rear, and acts as a brake when the drum is in operation. A manila cable from 1500 to 2000 feet long is attached to the drum underneath the draft pole and is carried down the slope by men and fastened to a log with grab hooks. The mules attached to the draft pole are started and, as the drum revolves, the cable is wound around it and the log gradually dragged up the slope. Logs are drawn over the escarpment, or other rough places in a chute made of logs. Trails are not cut out for the logs.

SNAKING EQUIPMENT

The first essential is a strong leather harness for horses and mules, and suitable yokes for cattle. Horses and mules when used in teams are coupled together in pairs and require a set of double-trees or a spreader and two single-trees for each team. For single animals a spreader only is required. When several teams are hitched one in front of the other a $\frac{1}{2}$-inch draft chain is required to which each double-tree is fastened. The draft chains for oxen are attached to rings on the yokes. Various devices, such as chokers, tongs and grabs, are used to attach the log to the draft power.

Chokers. — A choker is a chain from 12 to 16 feet long, made from $\frac{3}{8}$-inch iron with or without a choker-hook on one end. When a choker-hook is used, the end carrying it is thrown

around the forward part of a log to be skidded and the chain caught in the throat of the hook (Fig. 30, *a*.)

When the chain has no attachments, one end is thrown around the forward end of the log, looped around that part of the chain which is to be attached to the draft, after which it is wrapped several times around the chain encircling the log. When power

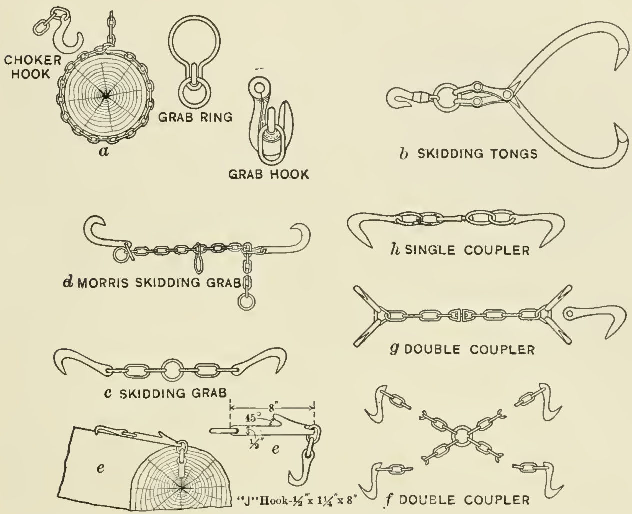

FIG. 30. — Various Forms of Equipment used in Snaking Logs. *a*, a chain choker. *b*, skidding tongs. *c*, a common form of skidding grab. *d*, a patent skidding grab. *e*, the "J" hook used to attach the tow chain to a turn of logs. *f* and *g* two forms of double grabs or couplers. *h*, a single grab or coupler.

is applied to the draft end of the chain the noose around the log tightens and prevents it from slipping. The choker may be used for single logs, or several small logs may be bound together in a cluster with one chain. It is very serviceable because it is readily adjustable to any size of log.

The draft end of the chain may be attached by a hook to a ring in the yoke of the rear pair of oxen, or to a ring on the

double-tree or spreader when other animals are used. If the chain is not supplied with a hook, the ring on the double-tree to which the chain is attached is made with a narrow throat in which a link of the chain is caught and held securely. The ring is often replaced by a grab hook in which the chain is gripped. The two latter forms of attachment are preferred because the chain may be lengthened or shortened at will.

Fig. 31. — A Turn of Logs at the Dump along a Skipper Road. The logs are fastened together with "single coupler" grabs. West Virginia.

Tongs. — Tongs which may replace chokers for handling medium-sized logs are made from round or octagon steel $1\frac{1}{8}$ or $1\frac{1}{2}$ inches in diameter, and have a spread of from 24 to 36 inches (Fig. 30, *b*). A $\frac{1}{2}$-inch chain link is attached to each short arm of the tongs and these links are connected by a 5-inch steel ring. In operation this ring is caught in a hook attached to the double-tree but occasionally a hook is attached to the ring on the skidding tongs, in which case the hook on the double-tree is replaced with a ring.

Grabs. — These are of several forms. The common skidding grab (Fig. 30, *c*) consists of two hooks each one of which is attached to a short $\frac{3}{8}$-inch chain which in turn is fastened to a ring made of the same size material. The hooks are driven into the wood on either side of the forward end of the log and grip it in a manner similar to a pair of tongs. The grab ring is attached directly to the spreader by means of a hook. The Morris patent skidding grab (Fig. 30, *d*) consists of a chain having a large ring at each end. The grab hooks are attached to the chain by narrow-throated links which may be set at any point in order to make the distance between grabs conform to the size of the log. The draft

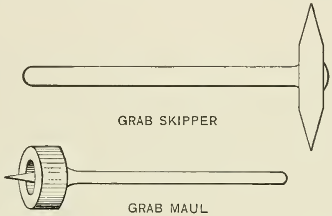

FIG. 32. — A Type of Grab Skipper and a Grab Maul used on a West Virginia Logging Operation.

power is attached to another narrow-throated ring which can be placed midway between the grabs and thus equalize the power. On steep slopes where logs are apt to run, a form of grab shown in Fig. 30, *e* is used. The spreader ring is attached to the "J" hook and when logs gain too great headway and threaten to run into the horses, the latter may be turned to one side, whereupon the tow of logs is uncoupled automatically. Grabs are also used to couple logs together in turns for transportation down skidding roads. There are several different patterns, including two forms of double grabs or couplers (Fig. 30, *f* and *g*) used for the forward logs where the strain is greatest, and a single grab or coupler (Fig. 30, *h*), for the rear logs.

A metal-banded wooden maul or a sledge hammer is used for driving grabs and a pointed sledge hammer, called a "skipper," for removing them.

CREWS AND DAILY OUTPUT

In the northern forests a crew usually consists of two or three teamsters, one or more swampers and one skidway man. One or more animals are assigned to each crew.

In the open pine forests of the South where there is a minimum of trail-building, one or more teamsters may work alone, doing their own swamping and skidway work. The usual practice, however, is to have swampers prepare the logs.

The daily amount of work, measured in thousand feet, log scale, performed by a team depends on the size of logs, the length of haul, the character of bottom and the grade. The size of log is an important factor because small logs show a low log scale in comparison to their weight and while several may be skidded at one time, their total scale may be considerably below that of a single log which can be handled as readily and in less time.

The number of logs skidded in a given time is not proportional to the distance. Animals when once in motion will consume less time traveling the second one hundred feet than they did the first, provided the log is not so heavy as to require stops every few feet. The time saved on the shorter haul may be lost very easily at the skidway or at the stump. A soft or rough bottom or one covered with large roots, stumps and other obstructions is prohibitive of speed and cuts down the daily output. Steep grades increase the number of logs that can be handled at one time.

When skidding with two animals, either horses or mules, and handling timber that averages from six to nine logs per thousand feet, log scale, a day's work, ten hours, ranges between 10,000 and 15,000 feet for distances up to 500 feet. A daily average of 10,000 feet during a month is considered good. For 750 feet the average ranges between 8000 and 12,000 feet, log scale and for 1000 feet, from 3000 to 4500 feet, log scale. A two-yoke team of oxen will average approximately the same number of feet per day as a good pair of mules or horses.

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CHAPTER XII

SLEDS AND SLED-HAULING

THE GO-DEVIL

SNAKING is frequently supplemented by the use of sleds.

A sled known as a go-devil, travois or crotch is employed in the eastern part of the United States during the summer and early fall and sometimes in the winter.

FIG. 33. — A Go-devil loaded with Hardwood Logs. Michigan.

The go-devil is a product of the camp blacksmith shop. It is a rough sled having two unshod hardwood runners, which are preferably of yellow birch, selected from timbers having a natural crook. The usual type of runner is from 6 to $7\frac{1}{2}$ feet long, 6

inches wide, and from 3 to 5 inches thick. A 6-inch by 6-inch by 4-foot or 5-foot bunk is fastened to each runner by a bolt. The bunk is placed from 2 to $2\frac{1}{2}$ feet from the rear end of the runners. A ring is attached to the center of this bunk and the logs are bound on the latter by a chain passing around the logs and bunk and through the ring. The curved, forward ends of the runners are connected by a roller which has a short chain at each end that passes through a hole in the forward end of the runner and is fastened several inches back on it. Since the go-devil has no tongue it can be turned around in a small space. The draft rigging consists of chains fastened to either side of the bunk or to the runners. The chains are brought forward and joined directly in front of the roller by a ring to which the hook on the double-tree is attached.

Since go-devils are loosely constructed, there is considerable backward and forward play in the runners and if one of them becomes obstructed the other moves ahead and starts it.

Go-devils are seldom used for distances less than 300 feet, except under adverse snaking conditions. They may be used for a quarter of a mile on snow but are not as economical as larger sleds for this distance. Trails are required and these are cut by the swampers as they prepare the logs for skidding.

THE LIZARD

A crude form of sled called a lizard is sometimes used in the pine forests of the South when the ground becomes too soft for wheels. They are not serviceable on very muddy ground because the nose digs too deeply into the soil.

The lizard is made from the natural fork of an oak, hewed flat on the upper and lower side, with an upward sweep on the forward end so that it can slide over obstructions easily. About two-thirds of the distance from the front end the two prongs are spanned by a bunk bolted solidly to them. The draft chain is fastened to this bunk and also passes around the log and through a hole in the upturned nose. Lizards are made in the camp blacksmith shop.

YARDING SLEDS

It is often desirable to yard or skid logs for distances over a quarter of a mile, especially when the amount of timber does not warrant the construction of a two-sled road, or the haul from the stump to the landing or to the railroad does not exceed $1\frac{3}{4}$ miles and the grade is favorable.

Snaking and go-devils are replaced in such cases by yarding sleds or drays in the Northeast and by a "jumbo dray" or a "bob" in the Lake States and the Adirondacks.

FIG. 34. — A Yarding Sled used in the Northeast.

The yarding sled is made by the camp blacksmith and consists of a pair of yellow birch or maple runners, 7 feet long, 3 inches wide and shod with $\frac{1}{8}$-inch steel shoes. The forward ends are curved upward. The runners are held together by a bunk 8 inches square and 4 or 5 feet long, placed about 3 feet from the rear end of the sled. In order to facilitate handling the sled the bunk is made in two parts; namely, a lower stationary bar fastened securely to the runners by pins, called "starts," and braced by heavy iron straps or "raves," and an upper bar which

is temporarily removed when the sled is turned around in the woods. The upper bunk has grooves cut on the ends or on the sides, and these grooves fit around the starts, which are mortised in the lower bunk and fastened to the runners.

Several logs with the forward ends supported on the bunk and the rear ends dragging on the ground can be loaded on a yarding sled.

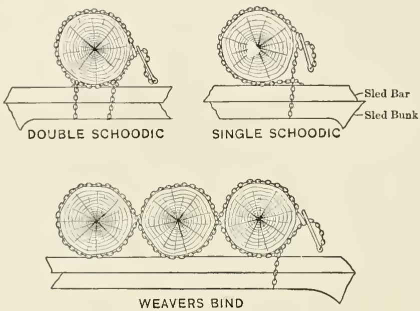


FIG. 35. — Methods of fastening Logs to the Bunk of a Yarding Sled.

The equipment consists of two $\frac{3}{8}$-inch chains 18 or 20 feet long which are used to fasten the logs to the bunk of the sled. Each chain has a grab hook on one end and a bunk hook on the other. The use of chains in binding logs is shown in Fig. 35. A third chain is sometimes used to bind the rear end of the load.

Two horses are used for hauling yarding sleds, except on long hauls or unfavorable grades, when four may be employed.

An average load is five large logs, or seven or eight small ones, the total averaging from 700 to 1000 feet, log scale. Five thousand feet is an average day's work for a team and sled on a haul of $\frac{1}{2}$-mile. The cost per thousand feet for teaming expense under such conditions averages from 75 to 90 cents.

THE BOB

In the Lake States and in the Adirondacks where yarding sleds are not used, a "bob" performs similar work. It consists of the front runners of a "two-sled," equipped with chains for

binding on the logs. It is adapted for hauls under three-fourths of a mile where the distance is too great for snaking.

From ten to sixteen logs may be hauled at one time on favorable grades.

THE "JUMBO"

The jumbo, a modification of the go-devil, is used on a snow haul in the Lake States, for distances not exceeding $\frac{1}{2}$-mile, where the conditions do not warrant the use of heavy sleds.

It consists of twin-sleds, similar in construction to go-devils, joined together by cross-chains, with a distance between bunks of about 9 feet. The runners are 8 feet long and have a $6\frac{1}{2}$-foot to 7-foot gauge. Two go-devils may be fastened together and used instead of special sleds. The jumbo will carry from 1000 to 1500 feet, log scale.

Roads must be cut out, stumps removed and swamps corduroyed, but the cost of road construction is less than for two-sleds.

THE TWO-SLED

The transportation of logs from the skidway to a landing on streams, to a railroad or to a mill is often effected by means of a heavy sled called the "two-sled," "twin-sled" or "wagon-sled." The gauge of sleds and minor features of construction vary with the weight of the loads, length of logs that are to be hauled and also with the ideas of the individual foremen, the essential features, however, being similar. Some prefer a wide gauge sled since the horses do not walk in the runner tracks and the latter can be kept free from manure.

A sled used on a Maine operation had runners $10\frac{1}{2}$ feet long, 4 inches broad, 7 inches high, which were shod with flat 4-inch steel shoes. The gauge was $5\frac{1}{2}$ feet. The runners were braced near the center by a transverse bar called a bunk, which was fastened to them by a wrought-iron casting, called a "dexter" or "sled knee." A rocker rested on the bunk of the forward sled. This rocker could turn around a king-pin that passed through it and the bunk. The forward runners were also strengthened by a flat roller rounded on the ends and fitted in circular holes in the sled noses. To this roller the sled tongue was mortised.

When two teams were used for hauling a sled, a false tongue was slung on rings under the main pole, projecting ahead far enough to accomodate the forward pair of horses. This pole enabled the lead team to assist in steering the sled. The rear runners were similar to the forward pair, with the omission of the tongue and rocker. Two-sleds are made from well-seasoned oak, maple or birch. The woodwork on a sled lasts from three to four seasons but the runner shoes must be renewed annually.

Photograph by E. B. Mason.

Fig. 36. — A Loaded Two-sled, showing the Binding Chains and a Potter (on the left). New Hampshire.

The front and rear sleds are often joined by two $\frac{1}{2}$-inch or $\frac{7}{8}$-inch chains attached to the back side of the forward bunk, directly over the runners, then crossed and attached to the noses of the rear runners. The length of the chains is adjustable so as to adapt the distance between the forward and rear bunks to the length of logs being hauled. On rough roads, when light sleds are used, and when logs of medium and fairly uniform length are being hauled, the cross chains may be replaced by a "goose-

neck," which is a V-shaped pair of thills. They have a hook on the apex by which they are attached to a ring on the back side of the forward bunk and the divergent ends of the goose-neck are fastened to the roller ends of the rear sled. The length of the goose-neck is from 16 to 18 feet, which gives a distance of 21 or 23 feet between the rear bunk and the forward rocker. When the empty sled is ready to return from the landing to the skidway, it is customary to unhook the goose-neck, turn it back on the rear pair of runners and couple the sleds close together by means of cross chains.

The cost of construction of a two-sled in a camp blacksmith shop, including labor and materials is between $50 and $75. Dealers in logging supplies quote them at prices ranging from $100 to $150.

SLED ROADS

Yarding Sled Roads. — Roads for yarding sleds are laid out by the camp foreman. Several main roads diverge from the skidways generally going up the slopes, and from these, branch roads are built directly to the logs.

Main roads are built 5 or 6 feet wide, stumps are cut level with the grade and all brush, fallen timber and boulders cleared away. The road is roughly graded, holes and depressions are filled with brush or dirt, streams are spanned with crib bridges, swamps are corduroyed and cross-skids are frequently placed across the road at intervals of from 10 to 20 feet to prevent the runners from cutting up the road. Side-skids may also be placed along the lower side of the road to prevent the sleds from leaving it. On side slopes, the outer edge of the road may be built up by laying skids parallel to the road and then placing short skids 2 or 3 feet apart across them. This crowds the sled towards the bank.

Main yarding roads are generally built by a special road crew. The secondary roads are laid out and constructed by the swampers while preparing the logs for skidding. Easy grades are desirable both for main and secondary roads, but are not absolutely essential because the speed of loaded sleds can be checked on steep pitches by a "snub-line" or a "bridle."

The snub-line consists of a $1\frac{1}{2}$-inch or 2-inch manila rope, one end of which is fastened securely to the load. The other end is given two or three turns around a stump at the head of the grade and gradually paid out as the sled descends, the speed being controlled by means of a brake on the stump.

A bridle is a chain passed around a runner in front of the bunk. It is put on and removed as circumstances demand. A clevis attached under the forward part of a runner sometimes replaces it. Bridles can only be used on smooth ground, otherwise the

FIG. 37. — Yarding-sled Trails leading down to a Skidway on a Two-sled Road. Maine.

chains catch on roots and other obstructions and stop the sled. Tail chains, which bind together the rear end of the load, also act as impediments and assist in the control of the sleds. Aided by any of these devices, teams with loaded sleds can go down slopes, up which they cannot return with empty sleds. The general scheme of roads is shown in Fig. 37.

The cost of constructing main yard roads ranges between \$60 and \$100 per mile.

Two-sled Roads. — The road system for an operation on which the logs are to be transported on two-sleds, comprises a main

road over which all the traffic passes to the landing, and secondary roads which radiate from it to the skidways. The roads are laid out by the camp foreman usually without the aid of surveying instruments, although in recent years, progressive woodsmen have adopted a hand level for the determination of grades.

The main road location is the more important because it is the route over which fully loaded sleds pass. These roads often follow the valley of some stream from the woods operation to the landing, crossing and recrossing the watercourse as often as

FIG. 38. — A Yarding-sled Road built up on a Curve to prevent the Sleds from leaving the Road. Maine.

necessary to maintain the desired grade. A minimum number of bridges is desirable because they are expensive to construct and to maintain. In order that logs can be hauled on a downgrade from the secondary roads to the main road, the latter should be located on the lower levels of the tract.

A main road of easy descending grades is preferred because on grades in excess of 5 per cent, heavy loads gain too much headway and it is necessary to place hay, straw, gravel, sand or brush on the road to check the speed. It is more satisfactory and often cheaper in the end to make cuts or to detour ascending grades rather than to return by them.

Dead-level pulls should be avoided because more power is required to move loads on such places than on gently descending grades. Sharp curves are especially dangerous on steep pitches because the load cannot be held in check by the animals and the sled is apt to leave the road under the momentum attained.

Turnouts are provided at the end of long, straight stretches on low-grade roads, while on steep mountain roads a "go-back" road is built on which the empty sleds return.

Secondary roads are inferior in construction to the main ones because they may be used for one season only, and a smaller amount of timber is brought out over them. Fewer roads can be used in a rough or rolling region than in a flat country because the downgrade permits skidding for longer distances.

Two-sled roads should be built during the summer or early fall before the ground freezes and snow falls. The days are then long and the unfrozen earth can be handled to best advantage. On new operations, road work follows camp construction, while on other operations the roadmen come in a short time in advance of the regular camp crew, or simultaneous with it. It is often necessary, however, to construct a tote road, from the base of supplies to the camp site, previous to the construction of the camp. Roadmen are chosen from the most inefficient workers in camp, because in such work little skill is required.

The right-of-way having been blazed out by the camp foreman, the "road-monkeys," as the men are called, proceed to fell a strip of timber from 20 to 30 feet wide along the proposed route. The merchantable timber is cut into saw logs which may be left at one side of the road, or skidded to the nearest skidway site. Depressions are filled with rotten logs and sound non-merchantable species. The latter are also used for corduroy, bridge construction and skids. Large stumps are grubbed, sawed level with the ground or blasted out; boulders are removed; and cuts are made to reduce heavy grades. Two-sled roads often present a rough appearance before snow falls, because of the uneven nature of the roadbed, but the first heavy snow fills the

depressions and smooths off the road making a solid bed over which the sleds may pass.

Swamps containing live springs are a source of annoyance when the road must pass over them, because they are the last part of the road to freeze over in the fall and the first part to thaw in the early spring, and should, therefore, be avoided when practicable. When the road crosses low marshy grounds or swamps, corduroy is used, which serves to give a broad bearing

Fig. 39. — A Two-sled Road, showing the Method of building up the Grade on Side Slopes.

surface to the road and prevents the sled runners from sinking into the mud. An average day's work for one man is to cut poles for and build one rod of corduroy. The cost ranges between 60 cents and $2 per running rod.

When roads are built on side slopes, the upper side is cut down and the lower side raised by laying long skids parallel to the outer edge of the road and placing short transverse skids on them. The space between the skids may be filled with brush, or left vacant and snow allowed to fill the interstices. On roads where the traffic is heavy the slope is either cut down enough

to make a solid roadway, or else an abutment of logs is built up on the low side.

Streams and dry watercourses are bridged with structures made from round timbers. Bridges are the first part of a sled road to weaken. They should be built on a slight downgrade, if possible, in order to facilitate the passage of loaded sleds. The usual type is one whose floor is supported on parallel stringers, from 12 to 15 inches in diameter resting on abutments and piers which are made of logs from 12 to 18 inches in diameter, built up in crib-fashion. The piers are 10 or 12 feet square and are commonly placed from 12 to 16 feet apart, and filled with stone to give them stability. The floor is made of skids from 6 to 10 inches in diameter, placed across the stringers close enough to form a solid roadbed, and on these a thick covering of bark is spread to hold the snow, and prevent the sled track from breaking up when the load passes over it. The skids are held in place by stringers which are laid on top of them, one on each side of the bridge.

Piers are not adapted for use in a stream bed, because freshets are apt to carry them away. Under such circumstances or where the bridge crosses a wide stream the cribs are placed from 20 to 25 feet apart and the stringers are supported between them by piles driven to bed rock at intervals of 8 or 10 feet.

When the stream is too wide for a single span, the cribs may be built in the water, heavily loaded with stone and provided with a "rake" on the upstream face to divert refuse and ice to either side of the crib. When long spans are employed it is customary to use five stringers. Deep depressions often are filled with cribbing built up to grade level.

On roads where the snow drifts badly snowsheds are occasionally built in order to keep the road open with a minimum of of hand shoveling. They also are employed on steep pitches to keep the ground free from snow, so that the speed of sleds can be controlled. Snowsheds are built in several different forms one of which is shown in Fig. 40.

The framework is constructed of poles 6 or 8 inches in diameter and heavy brush is placed on the sides and roof to prevent

the entrance of snow. The height and width of the sheds is dependent on the size of the sleds used and the maximum height of loads hauled.

The cost of two-sled roads ranges from $150 to $800 per mile, the average seldom exceeding $500.

Photograph by D. N. Rogers

FIG. 40. — A Snow Shed on a Two-sled Road. Maine.

They require at least from 8 to 12 inches of snow for successful operation and in the Lake States and the Northeast conditions are seldom favorable for their use until the middle or latter part of December. Hauling begins at this time and continues without interruption until the logs are all on the landing, or until the season breaks up and the snow leaves the roads.

Three machines play an important part in the maintenance of a main two-sled road; namely, the snowplow, the rutter and the sprinkler. They are frequently made by the camp black-

smith, but snowplows and rutters are also sold by dealers in logging supplies.

Plows are employed after each heavy snowfall to clear a right-of-way along the road wide enough to permit loaded sleds to pass. They are built in several patterns. A common type is V-shaped, with flaring sides 4 feet high which are bolted to a heavy pair of runners. The plow is drawn by from eight to sixteen horses. Patent steel snowplows weighing about 2000 pounds can be bought for $175. They can be made in camp for from $35 to $50.

The snowplow is followed by the rutter which cuts a square or round rut for the sled runners. The machine is mounted on a heavy set of runners and has two chisel-like blades which may be raised or lowered so that a rut of any desired depth can be secured. Snowplows and rut cutters are often combined in one machine, especially in those patterns offered by logging supply houses. A rut cutter can be purchased for from $100 to $115.

Long hauls, ascending grades and long, level stretches are iced so that larger loads can be hauled. A road on which four or more trips can be made daily is not iced unless a large amount of timber is to be hauled over it. Descending grades and secondary roads are not iced.

The sprinkler consists of a tank about 8 feet by 6 feet by 5 feet in size, built of dressed and matched plank, and mounted on a heavy pair of sleds. It costs about $50. The tank, which holds from 30 to 35 barrels of water, will sprinkle from one-fourth to one-third of a mile of road. A short piece of 1-inch iron pipe is fitted into each of the rear lower corners of the tank directly over the sled ruts. An overhanging piece of sheet iron is attached so that it hangs over the opening in the pipes and, when the wooden plugs are pulled out of the latter, the water plays on this sheet and throws a spray over the rut, which on freezing makes a solid ice coating.

A water heater consisting of a round wrought steel tube 18 inches in diameter equipped with a smoke pipe and a fire door is sometimes placed in the tank. A fire built in it prevents the

water from freezing. Sprinklers are filled either by gravity from a spring or brook, or else water is drawn up in a barrel by means of a cable and horse draft.

The rutting and sprinkling are done by a special crew who usually operate at night and whose sole duty is to keep the road in shape for hauling. Under ordinary circumstances, in addition to such men as are required continually at points where grades must be sanded, or snubbing devices operated, one man can keep two miles of main road in repair. One four-horse team and two men can operate the sprinkler on from 4 to 6 miles of road.

Fig. 41. — A Sprinkler being filled with Water from a Brook. Maine.

The average monthly maintenance charge on a 6-mile haul on a Maine operation was approximately $75 per mile. Other work required to maintain a two-sled road consists of shoveling out deep drifts after storms, banking and skidding up roads on side hills, where the sleds "slough" to one side and keeping a snow covering on bridges.

After one season's work a road requires a general overhauling to prepare it for the next winter's use. This work is done early in the fall at the time road building begins. Bridges are strengthened where necessary, the roadbed built up on slopes where weaknesses have become apparent, sags occasioned by the last

winter's haul are filled, and any general improvements made that the previous season's work have shown to be advisable, such as the elimination of undesirable curves and grades. This work costs from $25 to $100 per mile of road.

Operation. — The practice followed in preparing a main two-sled road for hauling varies somewhat on different operations. Preparation often begins two or three weeks previous to hauling, when a crew goes over the road filling in soft places and cutting out windfalls which may have dropped across the road. A forward pair of two-sled runners is then loaded with two small logs whose rear ends are allowed to drag on the road where the horses travel. Several loads of this character are hauled to the landing, followed by heavier loads again dragged on the same sled. When the road is thoroughly packed, a few light two-sled loads are hauled over the road after each snowfall. Just previous to the commencement of the main haul a rutter is run over the road followed by the sprinkler which makes an iced rut in which the sled runners travel. This preparatory work costs $10 or $12 per mile.

When hauling is about to begin, the roads past the skidways are broken out by a snowplow and if necessary by shoveling. Then an empty or lightly loaded sled is drawn over the road to break a track. The snow on the skidways is shoveled off and the empty sleds drawn by two or four horses are ranged alongside for loading. Logs are sometimes frozen so solidly that they cannot be loosened by hand and a small charge of dynamite must be exploded in the pile. On steep mountain roads it is customary to place partial loads on the sleds at the upper skidways and "top-out" the loads from skidways on the lower levels. Sleds are loaded by hand, by the crosshaul and by power loaders.

Hand loading is used where the logs are not large. It is a common method in the spruce forests of the Northeast. Two skids are placed so that they span the interval between the cribwork of the skidway and the sled bunks and the logs are rolled over the skids by the loaders. As the load is built up, the skids are raised and placed on top of each succeeding tier of logs.

Large logs are loaded with a team and cross-haul unless the skidways are higher than the sled bunks.

Horse loaders or "jammers" are frequently used in the Lake States. These consist of a derrick and swinging boom mounted on a heavy sled, equipped with hoisting blocks and tackle. The jammer is drawn from one skidway to another by a team, and is placed directly behind the sleds to be loaded with the boom so placed that logs may be gripped on the skidway with tackle, elevated and transferred to the sleds. Power for hoisting is furnished by the team which transports the jammer.

Power loaders are occasionally used in the Lake States. They are mounted on sleds and have a stiff boom and a hoisting engine driven either by steam or gasoline. They are transported from one skidway to another by animals and are used in a manner similar to the horse jammer.

Logs are bound on the sleds by chains. For high loads, operators use a set of ten chains: Four $\frac{1}{2}$-inch short bunk or corner bind chains which are used to bind the two outer logs of the bottom tier to the rear bunk and the rocker. Four $\frac{3}{8}$-inch "deck chains" each consisting of two parts. The first part is 24 feet long and one end is fastened to a ring on one side of the rocker or bunk. The other section is about 2 feet in length and is attached to the rocker or bunk on the end opposite the long chain. It has a ring on the end and a secondary chain with a grab hook attached also fastened to it. One pair of deck chains is used to bind the load after the second tier of logs has been put on, and the other pair after the fourth tier has been loaded. Two $\frac{3}{8}$-inch wrapper chains each about 40 feet long are passed around the completed load, but are not attached to the sled. The chains have a ring or bunk hook on one end and a grab hook on the other.

Where large loads are hauled, a "potter" is sometimes used to help bind the logs together. This is a round stick 3 or 4 inches in diameter and $2\frac{1}{2}$ or 3 feet long, around the center of which is fitted an iron clasp to which is fastened a short piece of chain with a hook on the free end. Where two pairs of deck chains are used, eight potters may be employed, four on each side

of the load. After the deck chains are placed on the first two tiers, the hooks on the potters are caught in links on each deck chain. The potters on the far side are held in a vertical position by a log rolled against them, while those nearest the skidway may be turned down until the sled is loaded, in order not to offer interference.

On well-maintained roads having favorable descending grades, four horses can haul from 5000 to 8000 feet per load, while two horses can haul from 2500 to 4000 feet. On unfavorable grades the capacity of four horses may be from 2000 to 3000 feet, log scale, and for two horses from 1250 to 1500 feet.

The number of daily trips made by teams for given distances is influenced by the weight and condition of the animals, the character of the road and the time required to load and unload the sleds. Horses tire on long hauls with heavy loads, consequently more timber can be hauled with lighter loads because of the greater speed possible. Horses cannot travel more than 24 miles daily for long periods, and this should be cut down to 20 miles when possible. The number of round-trips for a given length of haul is approximately as follows:

6-mile haul	2 round-trips
5-mile haul	2 round-trips
4-mile haul	2–3 round-trips
3-mile haul	3 round-trips
2-mile haul	4–5 round-trips
1-mile haul	6–7 round-trips

Steam Log Haulers. — As early as 1885 the attention of loggers was directed to the problem of introducing some form of mechanical traction to replace horses on long sled hauls, but it was some years before a satisfactory machine was placed on the market.

In 1889, Geo. T. Glover placed four log haulers on operations in Michigan. These were probably the first machines used for this purpose and, although they were not a success, they were the forerunners of the more recent ones that have proved to be of great value.

The first successful log hauler was patented by O. A. Lombard of Waterville, Maine, who adopted the general principles of the

driving gear on geared locomotives, substituting for driving wheels a special form of heavy traction device.

The essential features of the hauler are a locomotive-type boiler mounted on a heavy reinforced channel-iron frame, which also supports the cab and coal tender at the rear. The machine is supported in front on a narrow tread sled, which is so constructed that it may be run either forward or backward. A pilot, who sits on the front of the machine, steers the hauler by means of this sled.

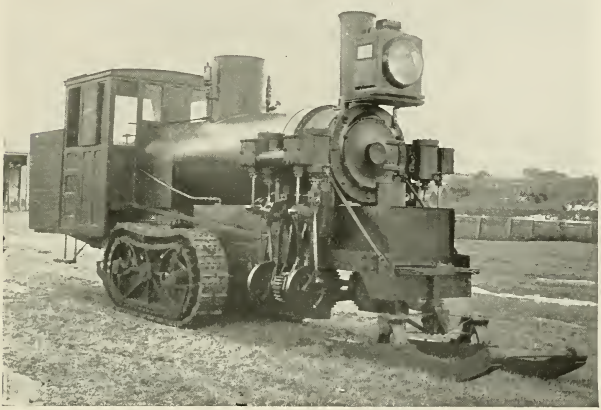


FIG. 42. — A Lombard Steam Log Hauler.

The weight of the machine rests chiefly on two special traction devices placed under the rear end of the boiler. Each consists of a heavy steel runner, hung on a $4\frac{1}{2}$-inch shaft and equipped on each end with a heavy box in which runs an iron shaft carrying a heavy steel sprocket wheel. Each set of sprocket wheels meshes into and carries an endless tread chain 12 inches wide and 14 feet long, which is armed with calks and furnishes the tractive surface. The weight of the engine is distributed over the surface of the tread chain by two tool steel roller chains, which

run in a tool steel channel attached to the underside of the steel runner inside of the tread chain. A bearing surface of approximately $4\frac{1}{2}$ square feet is given to each tread chain which is sufficient for tractive purposes and does not tear up the road.

The boiler which is equipped with locomotive boiler attachments is 15 feet long, 36 inches in diameter and is built for a working pressure of 200 pounds. The water tank is placed under the boiler directly in front of the fire box and has a capacity of ten barrels, which will run the hauler for 5 miles.

The engine has four vertical $6\frac{1}{2}$-inch by 8-inch cylinders which transmit power by a series of gears to the rear sprocket wheel on each runner. Two cylinders are placed on each side of the forward part of the boiler. The log hauler weighs from 17 to 22 tons when loaded with fuel and water. The average cost is $5000 each.

Steam log haulers are used extensively in the Lake States, in the Northeast and in Canada.

Some advantages possessed by the machine are that the annual depreciation and repairs are less than the depreciation on an equivalent number of animals; the necessity of bringing in large quantities of feed is obviated; and the machine can be operated day and night by employing two crews. Hauls exceeding 4 miles can generally be made cheaper with a log hauler than with animals.

The fuel most commonly used is wood because of its accessibility. Under average conditions a cord of 2-foot fairly dry wood will run a hauler approximately 8 miles, while a ton of soft coal will run it about 24 miles. Watering places must be provided along the road at intervals of from 3 to 5 miles.

The operation of a hauler requires a crew of from three to five men; namely, one engineer, one fireman, one pilot and one or two trainmen when from ten to twelve sleds are hauled.

The average speed with loaded sleds is $4\frac{1}{2}$ miles per hour, and with a train of empty sleds the speed is about 6 miles per hour.

The cost of road construction for log haulers is greater than for animals because stronger bridges must be built, steep down-

grades side-banked and timbered, and all curves strongly side-skidded to prevent the sleighs leaving the road. Sharp curves should be avoided because it is difficult to keep a train of sleds in the road.

On long, level hauls it is customary to rut and ice the roads to increase the hauling capacity. This may be done daily on the last return trip from the landing, the rutter and sprinkler being attached to the rear of the train. As a rule, however, the road is maintained by a separate crew.

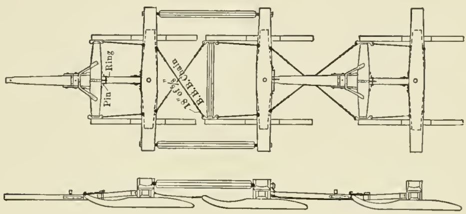


Fig. 43. — Type of Sled used with a Steam Log Hauler.

Sleds are made stronger than for animal haul because they not only bear a heavier load but are subject to severe strain in stopping and starting. The gauge is usually about 8 feet in order that the hauler may travel inside of the ruts.

Where the road has steep ascending or descending grades three or four sleds compose a "turn" because in the first instance the machine cannot pull loads of much greater weight and in the second, sleds have a tendency to "jacknife" and run out of the rut.

In mountain regions, steam log haulers are used on the main road only because the cost of constructing suitable secondary roads is too great. Sleds are hauled by horses to a central point on the main road and there made into turns for the log hauler. In a flat region the hauler may operate direct from the skidway to the landing, because of cheap road construction.

Rollways at landings should be arranged so that sleds can be run along the side of them and all be unloaded without respot-

ting. The hauler then need not remain during unloading but can at once start on the return trip to the skidways with the empties from the preceding turn. This method of operation necessitates the use of three sets of sleds; namely, one at the skidways, one on the road and one at the landing. The increased cost of equipment is more than offset by the greater capacity of the hauler and the decreased labor cost at the landing.

Haulers in the Adirondacks have carried fifteen cords of spruce pulp wood over roads having 10 and 11 per cent grades. Distance records of 84 miles in twenty-four hours have been reported. The heaviest loads have been hauled in the Lake States on ice roads. A single log hauler in Wisconsin has hauled fourteen sled loads of hardwood in one train, each sled bearing from 6000 to 7000 feet, making three or four trips daily on a round-trip of 12 miles. In Minnesota, trains of nine sleds, each bearing 12,000 feet of white and Norway pine, have been transported by one hauler.

The average cost of operating a hauler of this character in Ontario was $15 per day for coal and oil, and $15 for wages and board of the train crew. The hauler made three turns daily on a road between 7 and 8 miles long hauling from nine to twelve sleds per trip, an average of thirty loads. Each sled carried eighty logs, or a total daily haul of 2400 logs. The company estimated that the hauler did the work of twenty teams at a reduction of $25 daily for wages, and from $10 to $15 saving in the amount that would have been expended for horse feed. A further saving was effected during the summer months since idle horses cost from $25 to $40 each to feed while there is no expense for the hauler.[1]

A record[2] of one machine for a season's haul in Stetson Town, Franklin County, Maine, from January 11 to March 6, 1907, running day and night shifts, is shown in the following:

[1] See Logging by Steam in Ontario Forests. Canada Lumberman, Toronto, Ontario, Canada, September, 1911, p. 77.

[2] From the Mechanical Traction of Sleds, by Asa S. Williams. Forestry Quarterly, Vol. VI, 1908, p. 361.

Length of haul	7.5 miles
Total miles traveled	2850
Actual speed	4 to 6 miles per hour
Sleds hauled	551
Largest number of sleds in 1 turn	5
Total sleds used daily	21
Fuel used	350 cords of 2-foot hardwood
Elapsed time	65 days
Running time	53 days, 19 hours, 45 minutes
Lost time	6 days, 4 hours, 15 minutes
Total log scale	3,403,332 feet, log scale
Scale per sled	6225 feet, log scale
Scale per turn	18,052 feet, log scale
Largest train	37,710 feet, log scale

The saving by the use of the hauler was marked, since sixty-two horses would have been required to handle the same amount of timber.

CHAPTER XIII

WHEELED VEHICLES

Wheeled vehicles may be used where snow is not available as a bottom on which to move logs. They are employed for summer logging in the Lake States, and for year round logging in the South, Southwest, the sugar pine region of California and the Pacific Coast region.

TWO-WHEELED VEHICLES

Bummers. — A low truck called a bummer or self-loading skidder has come into extensive use in the flat and rolling hardwood and the yellow pine forests of the South, especially in Arkansas and Louisiana. A similar vehicle is also used in some places in the Inland Empire. In the South, bummers are often made by the camp blacksmith and have solid black gum wheels with 14-inch faces and a diameter of from 18 to 21 inches. Those offered by manufacturers of logging supplies have a skeleton wheel 24 inches in diameter with a 6-inch tire. The solid wheel is preferred by many, because it gives a greater bearing surface on soft ground.

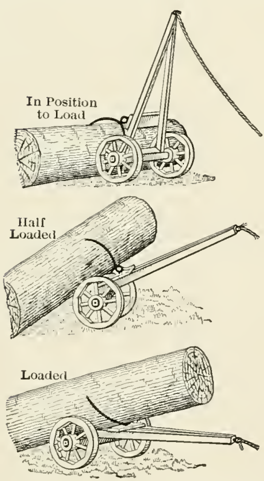


FIG. 44. — The Method of loading Logs on a Bummer.

Heavy steel axles support a wooden bunk from $2\frac{1}{2}$ to $3\frac{1}{2}$ feet in length and slightly concave on its upper surface. A tongue $5\frac{1}{2}$ feet long is attached to the bunk and serves both as a loading

lever and as a point of attachment for the draft power. Small logs are held on the bunk with chains and large logs either with tongs attached to the front face of the bunk or by a short chain to a breastplate on the tongue.

Bummers can be built by a camp blacksmith for from \$12 to \$15 each, and can be purchased from manufacturers for \$40 each.

In loading, a bummer is driven up to a log and backed around against it near the end. The tongue is then brought to a perpendicular position which permits the attachment of the tongs 3 or 4 feet from the end of the log (Fig. 44). The team is then hitched to a chain on the end of the tongue and is driven forward until the tongue has been brought to a horizontal position, which brings the log on top of the wheels. The trucks are turned by the horses until the log drops on the bunk. The load is then ready to start for the skidway (Fig. 44).

Unloading may be accomplished by a reversal of the process, or by disengaging the tong points by a blow from a cant hook or maul and dragging the bummer from under the log.

When several small logs are handled at one time, tongs are replaced with chains and loading is done from a rough skidway consisting of a single skid stick with one end raised high enough from the ground to enable the logs to be rolled on the bunks with cant hooks.

Bummers of this character may be used to advantage only in a region fairly free from brush, where the bottom is smooth and sufficiently hard to prevent the low wheels from miring and where gentle grades to the skidway can be secured. They are seldom used for distances exceeding 40 rods. Bummers are less serviceable than high wheels on ascending grades, since they pull harder.

In ten hours a bummer will handle from 8500 to 14,000 feet of yellow pine for a distance of 200 yards, and from 4000 to 6000 feet for a distance of 450 yards.

On an Alabama operation the crews operated in units of fourteen men and seven bummers, organized as follows:

1 foreman	2 swampers
1 loader	1 skidway man
2 "bunch" teamsters	2 "bunch" teams
7 bummer teamsters	7 bummer teams

The swampers cut the limbs from the logs and cleared out skidding trails for the bunch teams, which dragged the logs to central points available to the bummer teams; the loader assisted the bummer teamsters in loading, and a man was stationed at a skidway along the railroad to help the teamsters unload and "tail in" the logs to the forward part of the skidway.

In some sections of Arkansas a teamster, two horses and a bummer are assigned to each felling crew and handle the daily output of two men, skidding for a maximum distance of 600 feet from the track. Logs containing less than 150 feet are snaked and if the bottom is dry all logs above this size are handled with bummers. One swamper serves three or four skidding teams.

Log Carts. — In all types of carts the logs are swung beneath the wheels with the rear ends dragging on the ground. The height of wheels ranges from 5 to 10 feet with a corresponding variation in gauge.

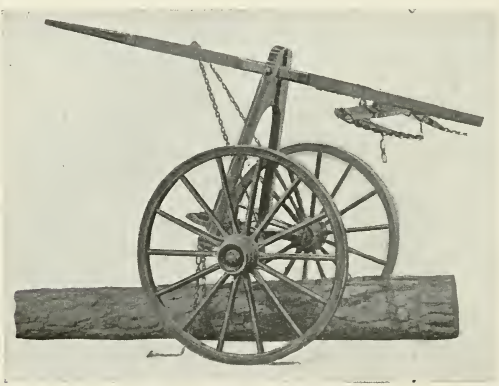


Fig. 45. — The Perry Log Cart in position to load. This cart has wheels either $4\frac{1}{2}$ or $5\frac{1}{2}$ feet high.

A cart used in the Coastal Plain region has an arched axle and wheels $4\frac{1}{2}$ or $5\frac{1}{2}$ feet high. The hounds of the cart are fastened on either side of the tongue by a heavy bolt. A bunk rests on top of the axle and carries two upright guides between which the

tongue fits. The latter is held in place by a spring latch. When the cart is to be loaded it is driven up to one end of a log, then backed until the axle is directly over that part of the log to which the chains or grapples are to be attached. The latch on the guides is then released, the team is backed for a step or two and the hounds are forced into a position nearly vertical, which turns the bunk through a quarter circle and brings it near enough to the ground to permit the grapples or chains to be attached. The elevation of the log is accomplished by driving the team forward, which brings the hounds and tongue to a horizontal position.

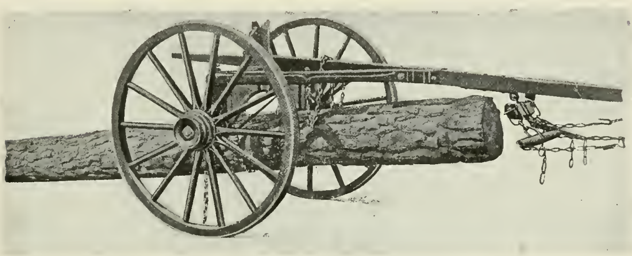


FIG. 46. — The Perry Log Cart loaded.

Wheels of this character may be used in a region where it would not be possible to snake, or to use bummers without swamping out trails. They may be driven readily over light standing brush or in down timber with a minimum of swamping. It is not customary to cut trails for them. The capacity of the wheels is one large, or from three to four small logs. Two horses or mules are employed for each cart.

Carts with larger wheels than those mentioned are in extensive use in the South, Southwest, Lake States, sugar pine region of California and, to a limited extent, both in the Inland Empire and in the Pacific Coast region. The wheels are from 7 to 12 feet in diameter and have tires from 5 to 10 inches wide. When one or two logs are handled they are suspended with grapples, and when several constitute a load chains are used.

The chief distinction between the several patterns of carts is in the mechanism for raising the logs from the ground.

One type in the southern pine forests has a tongue about 9 feet long. The chains holding the grapples are attached to a hand-winch with a horizontal axis which is mounted directly over the axles. The load is raised from the ground by revolving the winch with hand levers and it is kept from turning backward by a ratchet. When the carts are not loaded the animals are hitched short to facilitate hauling and guiding. Where large logs are being handled the cart is driven to the small end of the log, squared around over it and then backed to a point about midway between the two ends so that when the log is elevated the forward end will be clear from the ground and the rear end dragging lightly. If the log does not hang properly when elevated it is again lowered and the grapples attached at another point. The tongue of the cart is fastened to the log by means of a chain which is passed around it two or three times, then carried forward and wrapped around the front end of the log. The draft power is attached to the free end of the chain, or to a chain on the end of the tongue.

Another form of high wheeled log cart is one having a heavy wooden bunk and a tongue from 12 to 16 feet long. A chain is attached to the front side and passes over the top of the bunk, ending in a ring to which the grapple hooks are fastened. In operation the tongue is raised to a position slightly past the vertical, being prevented from tipping backward by a pole 10 or 12 feet long which is fastened on the upper side of the tongue, 3 or 4 feet in front of the bunk. The elevation of the tongue lowers the grapples to the ground so that they can be attached to the log. A team then pulls the tongue to a horizontal position, which raises the front end of the log clear of the ground. The tongue is then chained to the log, the horses attached to the front end of it and the load is ready to move. By using chains, several logs may be handled at one time.

Carts of this character are used for handling short hardwood logs in the Lake States, sugar pine in California and yellow pine in the South.

Another type known as the "slip tongue" cart has a tongue 28 or 30 feet long, which slides between the hounds of the cart. When the cart is in motion the tongue is held in a fixed position by a catch which the driver may release by a trigger when ready to load. There is a roller directly over the axle, to which the grapples are attached by chains. Fastened to this roller is a short lever arm which is connected to the sliding tongue by means of a chain. The cart is driven over a log, the catch holding the slip tongue is loosened, the team backed up and the

Fig. 47. — A Slip Tongue Cart in a Southern Yellow Pine Forest. Lever arm is elevated so that the grabs can be removed from the logs. Texas.

tongue slipped to the rear. The roller is so weighted that it revolves in a quarter circle, carrying the lever arm to a nearly vertical position. The grapples are then fastened to the logs and the team is started. The tongue slips forward, pulling the lever arm to a horizontal position, and raises the front end of the log from the ground. When the short lever arm reaches the catch on the tongue it is automatically locked. The team then starts for the skidway with the load.

High wheels of this character are especially adapted for a flat and rolling country with a firm, smooth bottom and an absence

of heavy underbrush. They are usually employed on hauls not exceeding one-half mile but occasionally are used for distances of from 2 to 2½ miles. In the pine forests of the extreme South they often are used when the distance does not exceed 100 feet. When used as a skidding rig in the southern pine forests they seldom require any road construction other than swamping out a trail through the slash along which the teams can pass. The forests are often sufficiently open to permit the passage of the carts without previous preparation. The practice prevails in some regions of felling the timber in strips, beginning at the back side of the skidding area where a strip from 100 to 200 feet wide is cut parallel to the railroad and then skidded. The work continues in this manner until the railroad is reached. This permits the teamsters to haul the greater part of the time through standing timber free from brush, which greatly facilitates the work. It is claimed by some loggers that the efficiency of a crew is increased 25 per cent by this method.

Roads are made and roughly graded in the hardwood forests of the Lake States where brush is abundant. Since short logs only are handled the roads need not be straight and boulders and stumps can be passed by a detour.

In the fir forests of the Northwest where high-wheeled log "sulkies" are sometimes used, a well-graded dirt road 25 or 30 feet wide, with gentle grades and easy curves is required. The cost per mile is about $1500.

From two to six animals are employed to haul log carts, depending on the character of the roadbed and the size and amount of timber hauled. Mules are preferred in the South, and horses in the North and West.

A crew in the southern pine forests often consists of three teamsters, one or two "bunch" teamsters, one or two swampers and one skidway man. The "bunch" teams yard the logs along the roads at places convenient to the log carts.

In the Lake States, two pairs of wheels and two bunch teams are used by a crew. The brushy nature of the country requires about four men for the swamping and other men with cant hooks to roll the bunched logs together into loads for each log cart.

In longleaf pine log carts drawn by two mules haul from 200 to 500 feet of long logs at one load. When four mules are employed, from 800 to 1000 feet may be handled, but six mules are required for over this amount.

In the Lake States the load for four horses ranges between 1000 and 1200 feet, log scale, with a maximum of 1800 feet. In the sugar pine region of California, from six to seven carts, each drawn by four horses weighing from 1500 to 1800 pounds are used in one camp and will put in an average of from 100,000 to 125,000 feet daily.

High wheeled carts range in price from $125 to $175 each.

WAGONS

Wagons are a desirable form of vehicle for stocking small sawmill plants, transporting timber to the railroad on large operations where the haul exceeds from 800 to 1000 feet, and for logging isolated tracts on which there is not sufficient timber to warrant the construction of a logging railroad.

They may be used to transport logs direct from the stump to the mill for distances of from 2 to 4 miles, although they are most extensively employed to haul logs from the stump to a railroad, stream or chute. The average length of haul in the flat and rolling pine lands of the South is approximately one-fourth of a mile.

Mule Carts. — In the Coastal Plain region, a type of 4-wheeled wagon called the "mule cart" is used on the uplands for hauling logs to the railroad. It consists of two pairs of trucks, the wheels of the forward pair being 4 feet, and the rear pair 6 feet, in diameter. The forward trucks have a straight axle and are equipped with a tongue of the usual length for a wagon, while the rear pair has an arched axle and bunk to which is attached a tongue which replaces the reach in an ordinary wagon. When the mule cart is loaded this tongue is chained down to a ring on the bunk of the forward pair of wheels. The logs are swung under the rear pair of wheels and only the forward ends of the logs are raised from the ground. The forward pair of trucks may be detached and used for skidding purposes, in which case

the log is suspended under the axle by means of grabs, or tongs. Mule carts do not possess any special advantages over a wagon, but are preferred because laborers are familiar with their use.

The usual maximum length of haul is 500 yards, but it is sometimes extended to a mile or more in scattered timber.

The average load per cart varies between 200 and 400 feet, log scale, with a daily output of from 3500 to 5000 feet, log scale, for a one-fourth mile haul. The cost of hauling and loading under these conditions will range between $1.50 and $2.25 per thousand feet.

Four-wheeled Wagons. — These are strongly constructed, with 32-inch to 38-inch front wheels and 34-inch to 40-inch rear wheels of wood or steel, 3-inch to 6-inch tires,[1] extension reach for

FIG. 48. — A Four-wheeled Log Wagon at the Skidway. Missouri.

handling logs of various lengths, heavy bolsters with adjustable blocks, stiff tongues for oxen and drop tongues for horses and mules, and cast or steel skeins, or steel axles. They have a rated

[1] Some loggers prefer 3-inch to $3\frac{1}{2}$-inch tires for two animals, and 4-inch to 5-inch tires for four animals.

carrying capacity of from 5000 to 15,000 pounds. Spikes are used on the back bolster to prevent the logs from sliding forward when hauling in a hilly region. Steel axles are not as popular as skeins, because of the difficulty of repairing them in the camp blacksmith shop.

Log wagon wheels are sometimes boxed with boards to keep mud from accumulating on the spokes. The box is constructed of rough boards nailed to the rims and closely fitted around the hub.

From two to five mules or horses, and from six to ten oxen are generally used for draft purposes, although heavy wagons are sometimes drawn by traction engines.

Four-wheeled wagons range in weight from 1300 to 2000 pounds and with cast skeins can be bought for from $115 to $175 each, including whiffletrees, evener and neck yoke, or tongue chains and stay chains. The bare wagon is offered by some firms for from $100 to $110 each.

In some parts of the Inland Empire very heavy log wagons are employed for hauling from storage yards or skidways to the logging railroad.

Wagons used on an operation in Montana had standard height wheels with 6-inch tires, bunks 6 feet long and 10 feet apart, with outer ends fitted with sway bars for the attachment of binding chains. The rear trucks were equipped with heavy hand brakes operated by a man who traveled on foot behind the load. From 2500 to 4000 feet, log scale, were loaded on the wagons by gravity from elevated skidways at the terminal of a log slide.

The road was one mile long and mostly downgrade, with some pitches of 6 and 8 per cent. Four horses were used for draft and each team averaged five round-trips per day between the railroad and the log chute and handled from 15,000 to 18,000 feet, log scale.

In the sugar pine region of California very heavy 4-wheeled trucks of twelve tons' capacity are used for log transportation when a traction engine is employed for draft power. These wagons have 54-inch solid or skeleton wheels, 20-inch tires, a short coupling tongue, and are equipped with hand brakes and

binding chains. From 5000 to 7500, feet log scale, may be loaded on one wagon.

Six-wheeled Wagons. — Wagons with six wheels have been placed on the market in the South in recent years. The rear trucks, which carry from 60 to 70 per cent of the load, consist of a rigid frame bearing two axles and four wheels arranged in the same manner as in the 8-wheeled type. The rear truck is connected to the forward one by the usual form of wagon reach. They are designed to carry heavier loads than 4-wheeled wagons, and to eliminate the heavy draft and difficulty in backing and turning in a short compass which are common to the 8-wheeled wagons.

They are quoted complete, f.o.b. cars at the factory at from $118 to $125 each.

Eight-wheeled Wagons. — Eight-wheeled wagons are in extensive use in the southern pine forests and in the hardwood forests of the Mississippi bottoms.

They are a heavy draft vehicle, more difficult to turn and to back than a 4-wheeled wagon but are capable of carrying a much heavier load because of the wide tires and the distribution of the load over eight wheels. They can be used on a dirt road sooner after a rain than can 4-wheeled wagons, and often a road will improve under 8-wheel traffic where it would deteriorate under that of four wheels. The bunks are also lower than on 4-wheelers and the wagon can be loaded more readily.

On short hauls four or five mules are frequently used with 8-wheeled wagons, but on long hauls they are not desirable for this type of wagon because of its heavy draft, oxen being the best, especially for heavy loads and on unfavorable bottom. From three to five yoke constitute a team.

Eight-wheeled wagons are successfully used with traction engine draft, three or four wagons each holding from 1000 to 1500 feet, log scale, constituting a train.

The distinctive features of an 8-wheeled wagon are the forward and rear trucks which on some types are rigid, consequently sharp turns cannot be made without dragging some or all of the wheels. Others have the front trucks so arranged that the two

sets of wheels can turn independently, thus reducing the resistance. All wheels are of the same diameter, varying in different vehicles from 32 to 36 inches in height.

The log bunks, with adjustable blocks, are supported midway between the wheels of each truck and project slightly above the wheels. A short reach is attached to the forward and rear trucks by flexible joints.

Eight-wheelers have an estimated capacity, on good roads, of from 9000 to 20,000 pounds weight. They weigh from 1200 to 1800 pounds.

Fig. 49. — An Eight-wheeled Log Wagon with a Load of Yellow Pine Logs. Louisiana.

The price of one type of 8-wheeled wagon ranges from $125 to $140, the variation covering differences in size of axles and tires.

Wagon Equipment. — The equipment used with log wagons on southern pine operations is as follows:

1 ax.
1 cant hook.
1 five-sixteenth-inch chain, 20 feet long, the ends of which are bolted to the bunks of the forward and rear trucks.
1 one-half-inch chain, 12 feet long, with a grab hook on one end and a loading hook on the other. This chain and the one above form the cross-haul used in loading.
2 hardwood skids about 9 feet long and 4 inches in diameter.
1 hickory binding pole.

Roads. — On short hauls the only preparation made for roads is to cut out a right-of-way through the brush. If the bottom becomes heavy for travel a new route is selected. Where a large quantity of logs must pass over a single route, a good dirt road is built on high ground, streams bridged, wet places corduroyed and sufficient repair work done to maintain it in good condition.

The best season for hauling is during the summer months, when the ground is dry and hard, for logging trucks can then handle maximum loads with the least amount of trouble. In swampy sections and on bottom-land logging often has to be suspended during the rainy period.

Hauling. — A common practice among companies who own their equipment and do their own logging is to work several wagons to a crew. The logs, after being swamped, are skidded with a bunch team to some place convenient to the wagons. The wagon teamsters then are concerned only with loading and hauling the logs. On small operations and where small contractors may be operating, each wagon teamster does his own swamping, bunching and loading. The former method is considered the more efficient.

On a haul of one-fourth mile, one bunch team can skid logs for two or three wagons, and for greater distances it can serve more teams because of the fewer number of trips made. Each wagon usually carries a pair of skidding tongs and, if the bunch team gets behind, the wagon teamster unhooks his leaders or the pole team and brings in a few logs. The number of swampers required depends on the character of the timber and the underbrush.

Wagons are loaded by the teamsters, who use a cross-haul rig.

On short hauls large logs are not bound to the wagon, but on long hauls or where the load consists of small logs it is customary to pass a binding chain around the load and under the reach. This chain is tightened by a hickory binding pole. The loading chains are wrapped loosely around the logs, the loading skids are placed on the reach, and the wagon is ready to start for the

skidway. Logs are unloaded by removing the binding chains, placing skids in position and rolling the logs off the wagon by means of cant hooks.

Hauling should be in charge of a team boss, who selects and directs the preparation of skidways and logging roads, determines the best method and equipment for hauling timber from particular sections, allots given crews to specified work, and sees that all men and animals are employed to best advantage. Skidways should be selected and prepared some days in advance of actual use so that the hauling teams will not be delayed by lack of storage space.

FIG. 50. — Loading a Log Wagon by means of the Cross-haul. Missouri.

On good bottom and level ground two horses or mules should handle from 400 to 600 feet per load and from 6000 to 10,000 feet daily; four animals should handle from 600 to 800 feet per load, and from 8000 to 12,000 feet daily. Five yoke of oxen will handle from 600 to 1000 feet of logs per trip, depending on the kind of bottom and the size of the timber.

The average number of trips daily for two horses or mules is approximately as follows:

$\frac{1}{4}$ mile and less	12 to 15 trips
$\frac{1}{4}$ to $\frac{1}{2}$ mile	12 trips
$\frac{1}{2}$ to $\frac{3}{4}$ mile	9 trips
$\frac{3}{4}$ to $1\frac{1}{4}$ miles	7 trips
$1\frac{1}{4}$ to $1\frac{3}{4}$ miles	6 trips

The contract prices[1] for skidding and hauling yellow pine are approximately as follows:

Distance.	Cost per 1000 feet.[1]
50–400 feet	\$0.50–\$0.75
$\frac{1}{4}$ mile	1.00– 1.50
$\frac{1}{2}$ mile	1.25– 2.00
$\frac{3}{4}$ mile	1.50– 2.50
1 mile	2.50– 2.75
Over 1 mile	3.50– 5.00

[1] Based on a single team and driver earning \$4 per day.

TRACTION ENGINES FOR WAGON HAUL

Traction engines are used for transporting logs from the woods to the mill where the amount of timber to be hauled is not great enough to warrant the construction of a railroad, where the grades are unfavorable for the use of animals and where timber of large size and great weight must be handled. They are used to a limited extent in the southern states but are more common in the Northwest and in California.

A traction engine to give the best results requires a good stone road but it works well on solid earth bottom. The ordinary 4-wheeled type is not successful in very swampy places, on very rough roads or on dirt bottom during rainy periods because the traction wheels soon render the road impassable.

Four-wheeled. — This traction engine has a locomotive-type boiler carrying about 165 pounds' steam pressure, and is equipped to burn either coal, wood or oil. The boiler and other parts of the engine are mainly supported on two traction wheels running on axles attached on opposite sides of the fire box. The diameter

[1] For logs averaging 10 per thousand feet. For logs running from 15 to 20 per thousand add from 15 to 20 cents per thousand to above prices. For oak add 50 cents per thousand.

of these wheels is ordinarily between 5 and 6 feet. The width of tire is governed by the character of bottom over which the engine is to travel. On ordinary roads from 20-inch to 24-inch tires are satisfactory even for the largest machines.

The forward part of the engine is supported on a pair of wheels $3\frac{1}{2}$ or 4 feet in diameter with from 6-inch to 10-inch tires. These wheels carry only a small proportion of the total weight, their chief function being to aid in steering. This is done by means of a hand wheel placed at the rear of the engine in close reach of the engineer.

The engine which develops from 20 to 30 horse-power is usually of the single cylinder type with a heavy flywheel.

The daily fuel requirements range between $1\frac{1}{2}$ and $2\frac{1}{2}$ cords of hardwood, or between 1 and $1\frac{1}{2}$ tons of coal. About 2500 gallons of water are needed for the above amount of fuel.

On a Washington operation a 30-horse-power traction engine has made a daily round trip of 30 miles, hauling 20,000 board feet of green lumber up 15 per cent grades, and down 30 per cent grades. This is probably the maximum capacity of an engine of this type.

Holt Three-wheeled. — This type has been developed largely for use in logging on the Pacific Coast and has a return-tube water-leg horizontal boiler supported on an I-beam frame. Almost the entire weight of the machine rests on the rear traction wheels, each $7\frac{1}{2}$ feet in diameter with a 24-inch tire. The fore part of the engine is supported by a single 4-foot wheel used for steering. Provision is made for the operation of the steering gear both by hand and by power. A single cylinder 11-inch by 12-inch balanced valve engine is placed on top of the boiler, and at 165 pounds' steam pressure develops 60 horse-power. Power is transmitted to the traction wheels by chains, and either wheel may be driven independently of the other. This is especially advantageous in making sharp turns. A radius of 25 feet is practicable in operating a train of five cars.

Water tanks with a capacity of from 400 to 700 gallons are carried on the frame directly in front of the boiler. The average water requirement per day of ten hours is from 2500 to 3000

gallons. From $1\frac{1}{2}$ to 3 cords of hardwood fuel, 1 to $2\frac{1}{2}$ tons of steam coal or from 200 to 300 gallons of fuel oil are required.

A special type of 3-wheeled wagon is often employed for hauling logs and lumber with this engine. The front wheel is $3\frac{1}{3}$ feet in diameter, has a 12-inch tire and supports about one-fourth of the load. The remainder of the weight is borne on two rear wheels each $4\frac{1}{2}$ feet high and with 16-inch tires. The load is borne on a frame built to carry from 10 to 12 tons.

Fig. 51. — A Holt Three-wheeled Traction Engine hauling Sugar Pine Logs. California.

The manufacturers claim that a 60-horse-power engine will haul a load of from 40 to 60 tons at a speed of from 2 to 3 miles per hour, ascending grades as high as 10 per cent. Thirty thousand feet of green lumber loaded on three trucks have been hauled up a 10 per cent grade, and 15,000 feet of logs have been hauled on two four-wheeled wagons over a rough log road down a 17 per cent grade. An engine hauling empty wagons travels 3 or 4 miles per hour.

Caterpillar Gasoline Tractor.[1] — This type represents a departure from the ordinary form of engine, for the traction wheels are replaced by a special traction device similar in character to that used on a steam log hauler.

The front end of the engine is carried on a single wheel which also furnishes a means for steering.

The engine is a four-cylinder, four-cycle, water-cooled type with 6½-inch by 8-inch cylinders and at 550 revolutions per minute develops 45 horse-power. A 34-inch flywheel is attached to the main shaft and aids in maintaining an even speed. Power from this shaft is transferred to bevel gears on the rear of the machine, which in turn transmit the power by chains to the sprocket wheels in the traction device. A forward and reverse motion are provided and two speeds may be secured by shifting the gears. The high speed is 5 miles per hour, and the low and reverse speeds 2½ miles.

The tractor carries a fuel tank of seventy gallons, and a water tank of fifty-six gallons capacity. The latter is sufficient for four or five days' running. Either kerosene or gasoline is used for fuel, and from two to four gallons per hour are required, depending on the amount of labor being performed.

The weight of the machine fully equipped is about 8 tons.

This type of tractor is adapted to soft, sandy roads and steep grades where the conditions are unfavorable for the use of animals. The manufacturers claim that they may be operated to excellent advantage on any road except one on which many boulders are present. Loads of 18,000 feet of green lumber have been hauled over roads having 12 and 14 per cent grades.

A forty-five-horse-power gasoline tractor costs $3500.

[1] Manufactured by The Holt Caterpillar Co., Peoria, Illinois.

CHAPTER XIV

POWER SKIDDING

The first patent on power skidding machinery in the United States was granted on November 13, 1883, to Horace Butters of Ludington, Michigan, and covered an overhead cableway designed to get logs out of "pot holes" and swampy places in the white pine forests. Perceiving the feasibility of using a machine of this type in the cypress forests of North Carolina, the inventor built some machines which were mounted on scows and floated in the bayous and sloughs. They did not completely solve the loggers' problems since they were limited in range from 700 to 800 feet and consequently could not reach a large part of the timber.

In 1889, William Baptist put a ground system in operation in a Louisiana swamp. It consisted of two large drums and an engine and boiler mounted on a scow, from which an endless cable passed out into the forest for a distance of one-half mile. This later developed into the modern "slack-rope" system now used on pullboats.

A third method called the "snaking system" was a later development in the pine forests of the South.

THE CABLEWAY SYSTEM

This comprises a main wire cable, from 1 inch to $1\frac{1}{4}$ inches in diameter, suspended between two supports known, respectively, as the "head spar" tree and the "tail" tree. These are usually located from 600 to 750 feet apart, although the span is sometimes as great as 1500 feet. The greatest efficiency cannot be obtained at the latter distance, because lighter loads must be handled.

Head spar trees are located along the logging railroad at intervals of approximately 1000 feet. They are selected by the

foreman before felling operations begin, must be straight and sound, and should have a minimum diameter of 18 inches at 60 feet above ground. In order to make the spar more stable the trees are topped before the rigging is placed.

In recent years a cableway skidder with a heavy steel spar mounted on a skidder car has been placed on the market. This spar replaces the head spar tree required by the earlier type and is so constructed that it can be lowered to facilitate moving the

FIG. 52. — A Steel Spar Cableway Skidder showing Loading Boom in Front.

skidder from one set-up to another. The adjustment of the blocks and the guying of the steel spar require only from one to two hours, while a day is needed to take down the tackle, move the skidder and adjust the blocks to a new head spar. The great weight of the machine prevents its use on light or poorly constructed track.

Tail trees, which are also chosen before felling begins, are located from 150 to 250 feet apart and should be at least 18 inches in diameter at 30 feet above ground.

One end of the main cable is passed around the tail tree at a height of 25 or 30 feet and is then carried to a stump or tree in the rear to which it is made fast. The tail tree is braced with this cable and also with an additional guy rope. The other end of the main cable terminates in an eye near the head spar tree and is connected, by means of a clevis, to an extension cable which passes through a block attached to the head spar tree. The extension cable is fastened to a stump in the rear by a "block and fall" attachment, by which, with the aid of a drum on the engine, the main cable is tightened.

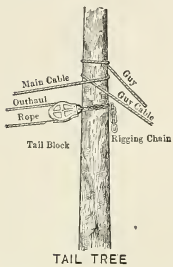
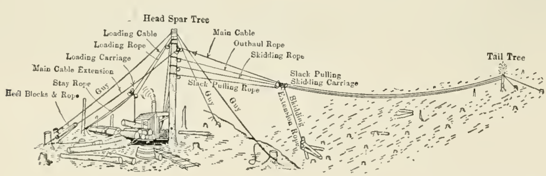


Fig. 53. — A Tail Tree showing the Method of attaching the Blocks to the Tree; also the Arrangement of the Guys.

The head spar tree is also braced by cables as shown in Fig. 54.

The trolley which travels back and forth on the main cable is operated by an outhaul cable and a skidding line. The outhaul cable is $\frac{5}{8}$- or $\frac{3}{4}$-inch in diameter and passes from a drum on the engine, through a block in the head spar tree, through the trolley and also through a block on the tail tree, after which it is brought back and attached to the rear of the trolley. It serves



By permission of the Lidgerwood Mfg. Co.

Fig. 54. — A Cableway Skidder showing the Arrangement of the Lines for Skidding and Loading.

to draw the trolley out along the main cable. The $\frac{3}{4}$- or $\frac{7}{8}$-inch skidding line passes from a drum on the engine, through a block on the head spar tree, then through a block on the trolley. It serve. as a point of attachment for tongs or other

skidding devices. The logs are dragged up to the main cable by this line, which also suspends them and serves to return the trolley to the head spar tree.

When the trolley is run out from the head spar tree, the skidding line sags between the two points of support and its weight pulls the tongs against the trolley. The line is either

Fig. 55. — Cutting the Top from a Head Spar on which is placed the Main Cable Rigging for a Cableway Skidder. Cypress Forest, Louisiana.

pulled down and dragged by hand to the logs to be skidded, an operation requiring the services of 5 or 6 men and involving a loss of time for the entire crew, or a patent slack puller is used which draws the slack out of the skidding line. A third $\frac{3}{8}$-inch cable is required for operating the slack pulling device.

Power for operating the cableway system is provided by an upright boiler and a pair of engines mounted on a steel frame,

which is supported on two sets of trucks, each of which is pivoted. The machine is moved from one set-up to another by means of a locomotive. On arrival at the location where it is to be used, the frame is elevated above the rails by hydraulic jacks, the trucks turned in a quarter circle, and a short span of track placed under each truck. The machine is then lowered and shunted off to one side of the railroad by the side of the head spar tree, where it is blocked up and remains until the next move is made. This leaves the main railroad track clear for the operation of logging trains.

The steel spar machine operates from the main track and may be either moved about under its own power or hauled on a car by a locomotive. In the first case the skidder is mounted on a steel frame supported on heavy trucks to which power is transmitted by a drive chain. In the second case the skidder is mounted on a steel frame which is carried on a set of specially designed flat cars. During operation the machine is elevated above the cars by means of hydraulic jacks, and supported at the corners by blocks. These cars are then pushed to the rear of the machine so that empty log cars can be brought under the forward part of the skidder for loading.

The three main drums on the skidder are arranged in a row in front of the boiler. The forward drum handles the slack pulling cable, the middle one the outhaul cable and the rear one the skidding line.

In operation the outhaul and skidding drums are interlocked, and when the outhaul cable is wound on its drum, the trolley is drawn out towards the tail tree, carrying with it the skidding line and the slack pulling line. When the trolley reaches the point at which logs are to be secured the drums are stopped and the interlocking device freed. When the slack pulling line is wound on its drum it operates the slack puller which runs out the slack for the skidding line. The latter is then carried to a log, or logs, which are attached to it by tongs or chokers. Logs can be drawn in a distance of from 60 to 75 feet on either side of the main cable by the attachment of short extensions to the main skidding line. When the logs have been pulled in near the main

cable the short lines are detached and the logs coupled directly by tongs or chokers to the skidding line, which is then wound in, and the log elevated wholly or partially from the ground. This is accomplished by holding the outhaul in a fixed position by a friction brake, until the log is in the position desired. The skidding and outhaul drums are then interlocked and as the skidding line is hauled in, the outhaul rope runs out, and the log is held suspended. On arrival at the railroad the logs are dropped in reach of a loading cable, and the trolley again returned to the woods for another load.

Logging rotates around the head spar tree and from 18 to 22 tail trees are usually employed for each set-up, an area of from 25 to 40 acres being logged from one spot.

When the steel spar skidder is used it is not feasible to log in a complete circle because of the difficulty of operating lines on the rear side of the machine. As a rule, an arc of from 275 to 300 degrees is covered.

In order to prevent the fouling of the cables in very brushy regions it is necessary to cut runs 5 or 6 feet wide, extending from the head spar to each tail tree. Such work is usually done a short time in advance of skidding. One man can cut the runs when the brush is of medium size.

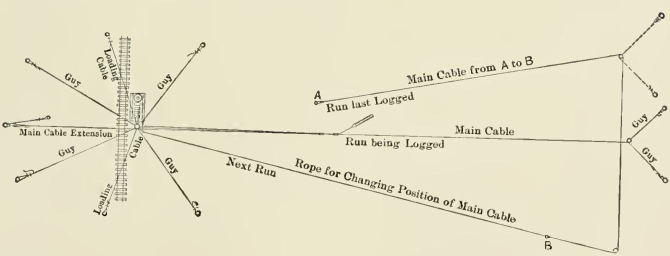


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Fig. 56. — Method of Shifting the Main Cable from One Run to Another.

Two main cables are employed. While one is being used, the rigging crew, composed of three men, is at work preparing the new tail tree and placing the extra main cable in position on

the next run. When the timber available to one run is skidded, the main cable is dropped to the ground and disconnected from the main cable extension; the trolley is placed on the new cable, which is then connected up to the cable extension, and the whole drawn taut for operation. It requires from 15 to 30 minutes to make this change. The rigging crew then proceeds to transfer the extra main cable to the next run. A block is placed on the new tail tree and a $\frac{3}{8}$-inch cable is dragged from the engine out over the new run, either by hand or by a horse. It is then passed through the block on the new tail tree, and finally through a block on the tail tree just abandoned. The end of the small cable is attached to the main cable and by winding the former on a drum of the engine, the main cable is dragged around into the new run, having reversed ends. It is then made ready for use by attaching it to the tail tree.

Many cableway skidders are provided with extra drums placed on the forward part of the skidder car, which are used for loading the logs on cars and for spotting empty cars under the loading boom. These drums are operated by an independent engine. The loading cable is $\frac{5}{8}$- or $\frac{3}{4}$-inch in diameter, and passes from the drum up through a block on the head spar tree, then through a block, directly over the log car, that is suspended from a cable fastened to the head spar and to a stump on the opposite side of the railroad track. The loading operation is independent of skidding.

The cableway system is especially adapted for logging in swampy regions where the bottom is too soft for animals; in very brushy sections; on steep and rocky slopes; in taking timber across canyons and gorges, or in bringing it up out of canyons to plateaus above or lowering it into valleys; in handling dense stands of small timber or heavy stands of large timber, especially where the physical conditions render ground systems difficult and expensive. It is operated to best advantage when the topography is such that logging railroads can be laid out at regular intervals, but it is also employed in very rough regions where the railroad must be placed in the valley or at the head of the slope.

This is the only system of power logging that is not very

destructive to seedling growth, although it damages standing timber.

It is most extensively employed in the swamp forests of the southern part of the United States. It is also used in the rough parts of the Appalachians; a few machines have been used in the spruce forests of the Northeast, the yellow pine region of the South, and they are coming into use in the fir forests of the Northwest.

The average daily capacity of a cableway skidder in cypress is from 35,000 to 45,000 feet log scale.

The crew for operating a skidder with a slack pulling device consists of 13 or 14 men, as follows:

1 skidder leverman	1 head rigger
1 fireman	2 rigging helpers
1 tong hooker	1 tong unhooker
1 or 2 helpers	1 run cutter
1 signal man	1 loading leverman
1 top loader	1 ground loader

If the machine is not supplied with a slack puller it is necessary to provide two or three extra men to assist in pulling slack and carrying the cable to the logs.

The cost of the fuel and labor for skidding and loading is from 85 cents to $1 per thousand feet.

A steel spar cableway skidder operating in a shortleaf pine forest in Texas, where the stand averaged from 3000 to 5000 feet per acre, logged 40,000 feet daily as a maximum. The average was not more than from 25,000 to 30,000 feet. Owing to the low stand per acre, the cost ranged from 90 cents to $1.25 per thousand feet.

The crew on this machine was as follows:

1 foreman	1 leverman
1 loader leverman	1 top loader
1 ground loader	1 fireman
1 tong unhooker	1 tong hooker
1 rigging slinger	2 helpers
1 helper	1 run cutter
2 woodcutters and haulers	1 night watchman

One horse was used by the rigging crew for hauling out cable and one team was employed by the wood haulers.

The timber on this operation was cut from 24 to 32 feet long and was felled without regard to the skidding direction. The head spar and tail trees averaged about 700 feet apart with a maximum of 1,000 feet; the number of runs per set-up ranged between 15 and 20, and the area logged from one set-up covered approximately 30 acres. From three to five logs were brought in at one time and were loaded on skeleton cars by a long swinging, end-control loading boom as shown in Fig. 52.

During the last few years the cableway skidder has been introduced with marked success on the Pacific Coast for handling small and medium-sized timber.[1] The machines are similar in type and operation to those used in the cypress region, although they are heavier and have a high speed for the return of the cables. They operate from a headspar tree and log an area of about forty acres at one set-up with a maximum working radius of from 900 to 1000 feet. The crew is as follows:

1 skidding leverman	1 loading leverman
1 fireman	1 woodcutter
1 tong hooker	4 riggers
1 helper	3 loaders
1 signal man	1 tong unhooker

The logs are skidded directly to a logging spur where they are loaded on cars by an auxiliary device similar to that described on page 202.

The average daily output ranges between 50,000 and 80,000 feet, for logs running between 500 and 1000 feet each. The daily wage cost per crew is about $48.

One manufacturer states that the cost of logs on the car is about one-third less than for similar timber logged with yarding engines. This is due to a reduction in the mileage of railroad spurs required and to the elimination of sniping, barking and road swamping.

THE SNAKING SYSTEM

This is a ground system in which the cables are taken to the logs by animals.

The essential features are an upright boiler with two, three

[1] The Timberman, Portland, Oregon, August, 1910, p. 36.

or four independent skidding drums mounted either on a heavy frame and trucks or on a frame which is supported at the corners on legs or "spuds." The first type is transported under its own power by a chain drive, and the latter type during transit rests on a flat car which is drawn by a locomotive.

The machine has a heavy pulling boom at one or both ends of the frame, from the peak of which blocks are suspended through which the skidding lines pass out. The pulling booms are guyed on either side to give them rigidity.

FIG. 57. — A Portable Snaking Machine operating in a Texas Longleaf Pine Forest.

Portable snaking machines are not equipped with a loading device but are supplied with a cable by means of which logs may be piled up along the track ready for a special loading crew.

When the snaking machine is not transported on its own trucks, it is equipped with a loading boom and the logs are loaded on cars as they are skidded. The machine is raised off the flat car by means of hydraulic jacks and then the corners are blocked up. The log cars are run under the skidder when they are brought to the woods and are pulled forward under the loading boom by means of a "spotting" cable as required for loading. The skidding cables are single lines which are carried by a mule or horse to the log to which they are attached by a

pair of tongs or a choker and then drawn in. The animal is ridden back to the machine and after the cable is detached from the log, returns the line for another log. Runs or trails are not cut.

The railroads are laid out in parallel lines from 1200 to 1400 feet apart and the timber is logged halfway back from each side of the track. The road is often placed on the higher ground because a better drained track can be secured and the timber can be pulled up hill as readily as down.

A common practice is to fell the timber in three strips beginning on the back edge of the area and cutting a section from 200 to 300 feet wide. This is skidded before the timber on the next strip is cut. The ground is thus kept free from débris and the timber can be drawn in easier than where there is slash to interfere. Trees are seldom felled with reference to the location of the railroad track although skidding of long logs is simplified if they are thrown away from the direction in which they are to be pulled, because the top then offers the least interference. The necessary swamping is generally done by the sawyers at the time the timber is felled.

When sawyers are paid by the thousand feet the timber is usually scaled at the stump.

A crew of seventeen men and nine animals, either horses or mules, is usually employed.

1 foreman	2 levermen
1 fireman	2–4 tong unhookers
4 tong hookers	4 riders
1 wood chopper	1 wood hauler
1 night watchman	

The foreman of the crew has general supervision of the operation and often acts as the leverman on the loading engine, when the skidder is equipped with one. Each leverman operates two drums on the skidder. The fireman performs the usual duties. The tong unhookers are stationed at the machine and detach the tongs or chokers from the logs as they are dragged in, attach the cable to the single-tree for hauling back to the next log; they also act as signalmen, transmitting orders from the

tong hookers at the stump to the levermen. The tong hookers attach the tongs or chokers to the logs, swamp an occasional limb when necessary, and control the speed of the log by signals to the leverman. The riders, usually negro boys, ride or lead the animals from the machine to the next log. The animals drag the cable to the desired point and then are brought back to the machine to repeat the process. The wood choppers and haulers cut and supply fuel for the boiler. The night watchman guards the machine at night, cleans up, and gets up steam in the morning ready for the crew. The top loader chooses the logs to be loaded and, standing on the car, directs their proper placement on the load. The ground loader places the loading tongs on the logs to be loaded, acting under the orders of the top loader.

If the skidder is equipped with a loader boom and engine the following extra men are required:

1 loader leverman, usually the crew foreman
1 top loader
1 ground loader

This makes a total of nineteen men for a full crew. Under favorable conditions the total cost of skidding and loading is from 75 cents to $1 per thousand.

Eight animals are used, four being worked from one to two and one-half hours and then allowed to rest while the others are in use. The ninth animal is used to haul the wood cart which transports fuel for the engine.

The daily capacity of each line is about 35,000 feet, with an average of 125,000 feet for a 4-line machine, where logs up to 40 feet in length are handled.

Daily records of 4-line machines, bringing in whole trees, have run as high as 295,000 feet. This amount, however, cannot be approximated as an average even under favorable circumstances.

THE SLACK-ROPE SYSTEM

This was developed largely in the cypress swamps of the South, where extensive areas of forest could not be logged with animals, and where railroad construction was not practicable. It is also very extensively employed on the Pacific Coast and to a limited extent in some other regions.

The system uses a heavy pulling cable, and a lighter one for returning the main cable from the skidder to the point from which the logs are to be dragged.

The power for the slack-rope system consists of an upright engine and boiler, and two large drums driven by a pair of powerful engines.

Pullboats. — In the cypress forests the slack-rope skidder is mounted on a large scow, and the machine complete, consisting of an upright boiler of from 60 to 80 horse-power with two engines operating two main drums and usually a third small drum, is called a pullboat. The large drums are placed tandem, one having a capacity of from 3000 to 4000 feet of from $\frac{7}{8}$-inch to $1\frac{1}{8}$-inch main cable, and the other at least twice as much $\frac{5}{8}$-inch messenger cable. An equal amount of $\frac{3}{8}$-inch line is wound on the small drum and is used to pull out the messenger cable when runs are changed. Four rings are spliced at 50-foot intervals to the main cable near the outer end and to these the chain and cables holding the logs are coupled.

Pullboats are anchored in canals, bayous or lakes and the roads radiate or "fantail" in a half circle for a distance of from 3000 to 3500 feet, although some of the larger machines can be operated for 4500 feet (Fig. 58). Distances in excess of 3500 feet usually are not regarded as desirable because breaks in the cable are more or less frequent and on very long hauls the loss of time in locating and repairing them is excessive.

The canals are dug by large dredges at a cost of from $3000 to $5000 per mile. They are from 40 to 50 feet wide, carry about 6 feet of water and are often several miles in length. Although at first intended solely for logging purposes, canals in recent years have been built with the idea of ultimately using

them for drainage purposes. The early operators had difficulty because they started to use the canals from the mill end, and so much débris and mud were drawn into the water, that frequent dredging was necessary to keep the channel open. The practice now is to dig the canal and begin logging at the far end, working toward the mill. Log barriers are now used, which prevent most of the refuse from falling into the canals.

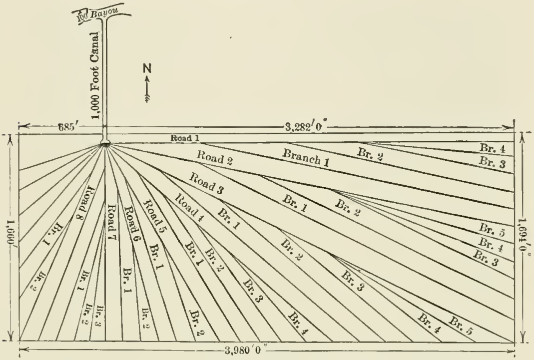

FIG. 58. — The Arrangement of the Roads down which Logs are pulled to the Pullboat. This system is known as fantailing. The figure is adapted from an actual operation in a Louisiana cypress swamp.

Pullboats operated from the shores of lakes or from wide bayous are moored to nests of piling driven off-shore, and the timber usually is pulled in straight lines.

In laying out a pullboat job it is necessary to locate and cut out main and secondary roads down which the logs are dragged to the canal or bayou. The foreman may locate the main and secondary roads on a map in the office before going to the field, and determine at just what points on the boundary roads will terminate, and the angle at which they should run toward the pullboat. The far end of the cable passes through a sheave block fastened to a tail tree. These should not be more than 150 feet apart; for logs cannot readily be side-lined for more than 75 feet. After determining on the map the approximate location of

the tail trees the foreman starts at some known point along the boundary, paces off 50 yards, selects the nearest suitable tail tree, and blazes it so that it will not be cut by fallers. He thus proceeds entirely around the tract. After the tail trees are spotted, the route of the roads is blazed out from the boundary towards the pullboat. On the completion of the work the roads will radiate out from the skidding center as shown in Fig. 58.

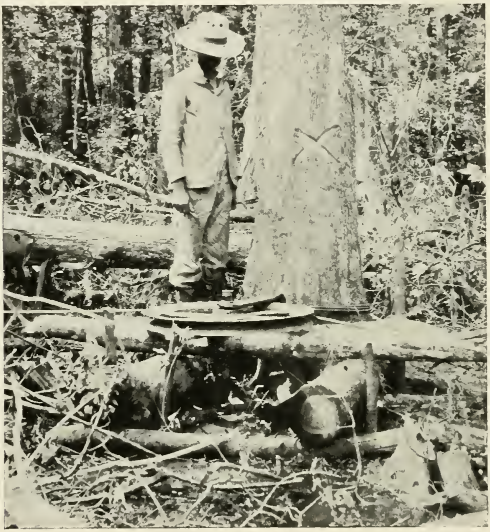

Fig. 59. — The Sheave Block attached to the Tail Tree. Note the method of supporting the block.

The great advantage of this system over the "every road a main road" method is that it greatly reduces the mileage of runs and is, therefore, much cheaper. The roads must be well cleared out, otherwise the logs will catch on stumps and other obstructions and cause numerous delays. They are usually cut out by contract at approximately 70 cents per 100 feet of road, with a further payment of 25 cents for every merchantable tree

felled and cut into logs. One man will cut from 60 to 500 feet of road daily, depending on the number of trees to be cut, number of stumps to be removed, and the amount of rubbish on the ground. Workmen regard road building as one of the more profitable forms of work in the cypress forest.

After the roads have been cut and the timber felled, the logs are prepared for pulling by a "sniping" crew, which may work by the day or by contract. The duty of this crew is to "snipe" the forward ends of the logs, bore two opposite 2-inch holes about one foot from the forward end of the log, and swamp out a trail so that the log can be dragged to the main road. A four-man crew will prepare from 75 to 100 logs daily and the contract price paid is about 8 cents per tree or log.

A pullboat having moved to a skidding site, the main and messenger cables are run out. A sheave block is adjusted at the far end of the road and two $\frac{3}{8}$-inch cables are carried from the pullboat to the sheave block; one end of the cable is passed through it and the two sections are then joined together. At the pullboat one end of the $\frac{3}{8}$-inch cable is attached to the messenger cable and the other end is reeled in on the small drum. This drags the messenger cable out over the road, through the sheave block and back to the skidder. The small cable is then detached and the end of the main cable fastened to the messenger. The pullboat is now ready for operation. When one road has been pulled, it is customary to change only the main cable, leaving the messenger in the first run logged until the distance between the sheave blocks becomes several hundred feet. It then does not get in the way of logs coming down the main road, is less subject to damage, and less time is required in changing runs. In changing from one run to another, the sheave block is left at the head of the first road and another is placed at the head of the next road to be pulled. The $\frac{3}{8}$-inch cable is carried from the pullboat out over the new road, through the sheave block and then across to the first run where the main cable is detached from the messenger cable, and the latter connected to the $\frac{3}{8}$-inch line. The main cable is drawn to the machine and, by reeling in the small cable, the messenger cable is pulled over into the new run

and along it to the pullboat. The messenger and main cables are again coupled together and the equipment is ready to log the new run. A piece of telephone wire strung along the outer edge of the run is used as a whistle cord and signals are given to the engineer by pulling on the wire. The sheave blocks are usually placed by a special crew before the change is made and the $\frac{3}{8}$-inch cable is run out by this crew unless the distance is long, when the entire pullboat crew is required. Ten or twelve men can string out 2600 feet of $\frac{3}{8}$-inch cable in about three hours.

The logs are prepared for skidding by the insertion of plugs or "puppies" in the holes previously bored by the sniping crew. Cylindrical plugs 2 inches in diameter and 12 inches long are connected in pairs by two sections of $\frac{1}{2}$-inch chain 24 inches long fastened to a 6-inch ring. The plugs are driven into the log and the ring on the plugs is fastened by a short chain to the main cable. The log is now ready to be hauled out to the main road. This requires some maneuvering if there are stumps, logs or trees in the line of the log being hauled, for the timber must be "side-lined" around them. When once the log is dragged into the main run, it is left there until a tow of four logs is secured. Each log is fastened by a short chain or cable to a ring on the outer end of the main cable. The boss then gives the order to go ahead, which the whistle boy transmits to the skidder and the logs start down the road.

During the early periods of modern pullboating a device called the Baptist cone was placed over the ends of logs to enable them to slip over or under obstructions. These cones were made of steel but were too heavy to handle, when made strong enough to withstand the rough treatment and they were abandoned, in favor of sniping. Tongs are not regarded with favor because they lose their grip as soon as the draft on the cable is lessened. When a tow that is being dragged down a main road is stopped, as it frequently must be, the tongs drop off and a man must be sent to readjust them. For this reason, plugs or puppies are preferred.

The crew of a pullboat is divided into two sections, one of

which attaches the logs to the main cable and the other operates the machinery and rafts the logs.

The woods' crew of seven men consists chiefly of negroes as follows:

1 foreman	3 side-line men
1 plug setter	1 whistle boy
1 head hooker	

The plug setter adjusts the plugs or puppies. The side-line men carry the skidding lines from the main run to the logs and connect them with the puppies. The head hooker's duty is to attach the logs to the main cable by short chains. The whistle boy transmits the orders of the boss to the engineer by means of a code of whistle blasts.

The crew at the pullboat consists of five men, as follows:

1 engineer	1 wood-passer
1 fireman	1 deck man
1 rafter	

The engineer and the fireman perform the usual duties. The deck man uncouples the logs as they are brought up to the pullboat, removes the plugs and chains, and poles the logs around to the rafter at the rear. He also attaches the removed chains and plugs to the main cable by which they are returned to the woods' crew. The rafter makes the logs up into cigar-shaped raft units about 125 feet long. The wood-passer supplies the pullboat with fuel wood which has been previously cut and piled along the banks of the bayou. A flat boat is used for this purpose. About three cords daily are required for a single boiler.

An average day's work for a pullboat crew is from fifty to seventy-five logs; the output is often less, however, because of cable breakage.

Yarding Engines. — In the Pacific Coast forests the slack-rope system is used on dry bottom. Two types of machines are employed, namely, the yarding engine and the road engine. The former is employed for skidding logs to a central point on a railroad, or to a skid or pole road down which they are hauled by the road engine. Yarding engines are built in various sizes, but a common one of the more powerful type has a 60 by 120-inch

vertical boiler operated at from 165 to 200 pounds' steam pressure, and a pair of 10 by 12-inch or 12 by 12-inch engines. The yarder is equipped with two drums, one about 60 inches in diameter with a capacity of approximately 1000 feet of from $\frac{7}{8}$-inch to $1\frac{1}{8}$-inch steel cable, and a smaller drum from 36 to 40 inches in diameter, carrying 2000 or more feet of $\frac{5}{8}$-inch steel cable. The engines, boilers and drums are mounted on skids about 3 feet in diameter and from 35 to 40 feet long. The larger yarding engines complete, including cables and other equipment delivered on the operation, cost from $3500 to $4000.

The method of operation is dependent largely on the topography of the region. The more common scheme is to build a landing at a suitable spot along the railroad and to install the yarding engine at one end of it. When the area tributary to this location is logged, the yarder is shifted to the opposite end of the landing. The yarder is brought to the site on a flat car and unloaded by means of cables and blocks, power being furnished by the yarder itself. In some cases, a road engine is installed at the landing from each end of which a skid road extends into the timber for from 3000 to 4000 feet. Branch roads are built from the main road and at the junction the yarding engines are placed. Another method is to build spur logging roads instead of skid roads and to use a geared locomotive to drag the logs over the ties to the landing.

After the swamper has bucked up windfalls which would interfere with dragging in the logs, and the yarding engine has been placed in position at the landing, the hauling lines are placed. The messenger cable is carried out to the end of a run,[1] six or eight runs ahead of the one in which yarding is to begin; it is then carried to the end of the first run that is to be logged and brought along it to the yarder and connected by means of a clevis to an eye on the main cable. Where the messenger cable turns an angle it is held in position by a snatch block fastened by a short piece of cable to trees or stumps. These blocks are made so that they can be opened and the line removed without displacing the block. The placing of the messenger cable several

[1] Runs are usually about 50 feet apart.

runs distant obviates a frequent change of position and also keeps it out of the way of the logs as they are being hauled in.

A cable or chain, called a "butt-line," "whip" or "butt-chain," from 8 to 12 feet long with an eye-splice and ring on one end, and a swivel and hook on the other is also fastened to the clevis on the trip-line. This hook on the butt-line serves as a point of attachment for the chokers, grabs or dogs which are used to grip the logs.

Where there are heavy pulls, devices called "fair leaders" which are built of several patterns, are employed to line the cable evenly on the drum of the yarding engines. These are attached to a framework placed just in front of the drums.

A crew of twenty-five or twenty-six men will yard daily about 60,000 feet directly to the railroad. The crew consists of the following men:

1 side boss	1 knotter
4 fallers	1 signal man
5 buckers	1 head loader
1 hook tender	1 second loader
2 choker men	1 spool tender
1 rigging slinger	1 yarding engineer
1 chaser	1 yarding fireman
1 swamper	1 wood-buck
1 sniper	1 block and stake maker

A side boss is not always employed, but when he is a member of the crew he acts as foreman of the felling and yarding crews. The hook tender is the boss of the yarding crew, and the amount of work done depends largely on his ability. He plans the work, shows the swamper where roads are to be cleared, designates the logs that are to be skidded and the order in which they are to be taken, and directs the rigging slingers in their work. The rigging slinger is the hook tender's assistant, and his duty is to place the "lead" and other blocks at the points directed by the hook tender. The swamper works just ahead of the yarding crew, cuts up rotten windfalls so that they can be gotten out of the way, chops out the larger brush, cuts roots and improves the runs so that logs can be brought out without being hung up. The choker men place the chokers around the logs, snipe the

ends of the logs if necessary and attach the chokers to the butt-line. The chaser follows the logs to the landing to see that they are not hung up en route, and to signal to the engineer in case there is need for stopping the engine. The knotter cuts limbs and knots from the logs before they are yarded. The head loader is boss of the loading crew and is assisted by the second loader and also by the spool tender who operates the loading drum on the yarding engine, or the separate engine when one is provided for loading. The block and stake maker cuts and shapes blocks to fit into the pockets on the log cars. The signal man stands near the hook tender and by means of signals, usually given by pulling on a wire attached to the whistle of the yarder, transmits the orders of the hook tender to the engineer. The wood-buck cuts fuel for the yarder from logs, tops or waste material.

The first work of the yarding crew, when starting on a new road, is to remove the material which is too large for the swamper to handle. This is called "chunking." The work of yarding logs begins when the road is cleared. The hook tender selects the log he desires and the choker men proceed to adjust the chokers, dogs or grabs to the log. A choker is a $\frac{7}{8}$-inch or 1-inch steel cable noose about 15 feet long, which is slipped over the forward end of the log. The free end has an eye-splice which is caught into the hook on the end of the butt-line. It is the most common form of attachment now used. Dogs are large steel hooks from 10 to 14 inches long, fastened together by a chain or cable 4 feet or 5 feet long. These are driven into the log and attached to the hook on the butt-line. They are most serviceable in small timber, but do not hold to the logs well on a heavy pull. Grabs are used in pairs and are connected by two links of a stout chain to a common ring. They are driven in notches cut on the sides of the log, and are so constructed that the harder the pull on them, the greater their tenacity.

When the logs are connected to the main cable by the butt-line the hook tender signals the engineer to haul in on the cable and the logs start down the road. Additional blocks and cables are attached to the butt-line, in case it is necessary to side-line

the logs around stumps or other obstructions, or to pull them backwards until they are clear. As the logs reach a snatch block on the road, the engine is stopped, the block opened, and the cable removed. The block is then placed around the cable behind the point at which the logs are attached. The logs then are dragged to the succeeding blocks, and the process repeated. When they reach the main road they are disconnected from the chokers, grabs, or dogs, by a coupling-up man belonging to the road-engine crew and the main cable is again returned for more logs.

A day's work for a yarding crew varies with the size of the timber and the difficulties of logging, but averages from 40,000 to 60,000 feet.

Coal and wood have been the common fuel for donkeys until recent years. Oil burners are now in extensive use and electric drive is rapidly being developed, although it is still in the experimental stage. The advantage of fuel oil is that forest-fire danger is eliminated, and operators claim the efficiency of the yarding engines is increased from 15 to 25 per cent with a considerable reduction in logging expense. Records of tests with fuel oil reported at the Fourth Annual Meeting of the Pacific Coast Logging Congress[1] showed that on the operations of one company the saving in the use of oil as compared with wood was from 9 to 17 cents per thousand feet due to increased efficiency, saving of good timber formerly used for fuel, and a reduction in the force required to operate the yarder.

The cables used for skidding are of plow steel, and their life is dependent largely on the care they receive. When kept properly oiled and operated under average conditions a main cable will handle about 5,000,000 feet.

A modification of the standard yarding engine is one known as the Duplex logging engine.[2] This consists of four drums, mounted in pairs and tandem on a 9-inch shaft; a single vertical 72-inch boiler and two 11- by 13-inch engines. It is in reality two separate yarding engines under the control of one engineer.

[1] The Timberman, Portland, Oregon, August, 1912, p. 40.

[2] See The Timberman, July, 1911, p. 55.

This machine has been developed in the redwood region, and is said to have the following advantages:

(1) It enables the simultaneous operation of two different gulches by one machine which is run by a single engineer and a fireman.

(2) On long hauls the time can be reduced by yarding logs for a portion of the way with one set of cables, and then bringing in the logs with the other set. The long distance line is returned for another turn of logs while the second one is dragging the first turn to the landing.

(3) One cable can be used to yard logs located at a sharp angle from the main road. The logs are dropped at the blocks on the main road and picked up with a minimum loss of time by the second line.

So far as known this system is not in extensive use.

Road Engines. — Road engines are semi-permanent in character and are not subject to as much strain in movement as yarding engines. They may be mounted on skids or on a heavy frame of timbers, and are operated for distances not exceeding $1\frac{1}{4}$ miles. They use cables of a size similar to those employed on yarding engines.

Road engines may be used singly, in which case they are located at the landing along a railroad, stream or at the mill; or they may be used in batteries of two or three. The rear machine hauls the logs up to the tail block of the succeeding road engine, which in turn hauls them to the next one.

It is seldom economical to employ more than two or three machines in a battery because of the great expense for cable and labor in comparison with the output. Railroads are always built up to the first road engine, if possible, because of the reduced operating charges.

The general features of a road engine are similar to those of a yarding engine except that the machinery is more powerful and capable of operating for longer distances. The specifications of one of the larger types of road engines are a 72- by 132-inch boiler; 13- by 14-inch cylinders; 165 or 180 pounds' working pressure; and a capacity of 7500 feet of $1\frac{1}{8}$-inch cable.

The main cable is 1 inch or $1\frac{1}{8}$ inches in diameter with a $\frac{5}{8}$-inch messenger line. The cable is operated on the slack-rope system with the road engine located at the landing and a heavy tail-sheave at a point a short distance above the yarding engine. The messenger line which is placed near the main road but outside of it so that it will not interfere with the operation of the main cable is hung in snatch blocks located at suitable points. The main cable follows the road and is kept in place by blocks or by rollers where turns are made. Several logs aggregating from 6000 to 11,000 feet log scale are fastened one behind the other by grabs, and form turns which are attached to the main cable by a chain or short piece of cable which is coupled to the grabs on the forward log. The turns are made up by a grab setter. A chaser follows the logs to the landing, often riding in a rigging sled hollowed out of a log, which is attached to the rear log. The chaser can signal to the road engineer at any point along the line by pulling on a wire stretched along the road which is connected to a bell or to the whistle on the engine. On arrival at the landing the chaser aids in placing the logs on the landing, removes the grabs from the logs and returns with the grabs in the rigging sled to the yarding engine.

A road engine requires a good road, because the route is used for some time, and when the haul is long it is desirable to handle maximum loads. The roads are constructed in two different ways, one of which is known as the skid road,[1] and the other as the fore-and-aft or pole road.[2] Both forms may be used on different stretches of the same road, because skids are preferable for level or ascending grades, and pole roads for rapidly descending ones. The skid road requires a right-of-way from 12 to 14 feet wide, which is swamped out carefully and graded to avoid abrupt changes. It is better to make cuts than fills, because a more solid foundation is secured. Skids from 10 to 14 feet long and from 15 to 24 inches in diameter are cut, and skidded along the right-of-way by a yarding engine assigned to road work. The skids are laid in transverse trenches 8 or 9 feet apart and

[1] See page 149.

[2] See page 233.

earth is tramped around them to make a solid bed. Where there are sharp pitches and the logs are apt to dig into the ground the skids are placed closer together. Saddles or hollows are adzed out in the center in which the turn of logs is dragged. The skids are elevated on the inner side of a curve to prevent the logs turning too sharply. Some prefer to lay the skids flat and secure the necessary elevation by means of short sheer skids. The advantage of this method is that a change in pitch at the turn can be more readily accomplished than when the main skids must be changed.

The road should be as straight as possible because curves increase friction, reduce the hauling ability of the engine and also cause greater wear on the cable. Where there are turns in the road, either rollers are placed on stumps or posts, or fenders are put alongside the road to prevent wear on the cable. Rollers may also be employed on top of ridges to prevent wear from downward pressure, and suspended rollers may be used to hold the cable down at the foot of slopes.

On low ground skids are laid on stringers or cobwork into which they are firmly notched and the skids are also braced by short pieces of timber. Hemlock is frequently used for skid timbers because of the low value of the stumpage. About 80,000 feet of timber, exclusive of bridges, is required per mile of skid road and the cost for labor ranges from $1000 to $1500 per mile.

Hauling by Locomotive. — On some operations the road engine is replaced by a geared locomotive and the logs are dragged between the rails from the yarding engine to the landing. As a rule the logs are dragged directly over the ties, but on a road of some permanency planking is nailed on the ties to protect them.

A plan sometimes followed is to have a spur track from one-half to a mile long running out from each end of the landing, with a donkey working at some point on each spur. The engine goes out one spur and with a short cable couples to a turn of logs, made up in advance, and drags them down to the landing. It then goes out the other spur and brings in a turn from it, alternating in this manner throughout the day. A water tank with a $1\frac{1}{2}$-inch escape pipe is sometimes used to wet the track to

facilitate the passage of the logs. On a 1-mile haul one engine can handle daily the output from two yarding engines, or from 90,000 to 100,000 feet.

Dudleys. — On grades too steep for locomotives a special type of locomotive known as a "Dudley" or "Dudler" (page 301) is often used, either to drag the logs over the ties or to haul log cars up or down steep grades.

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CHAPTER XV

AERIAL TRAMWAYS

Aerial tramways are used for carrying logs and other forest products up or down steep slopes, where other forms of transport are not feasible.

The most common type used in the United States has a stationary main cable which is stretched between the terminals of the tramway and may consist of a single span or be supported at frequent intervals on trestles. The trolleys carrying the loads run on this cable.

On gravity trams the route need not run in a direct line provided there are stations at each sharp angle where trolleys can be switched from one cable to another. Where power is used to move the loads the line must be straight, or else separate power must be provided for each straight section of cable. Vertical curves are permissible when sufficient momentum or power is available for carrying the loads over depressions. The average grade for gravity tramways is from 25 to 30 degrees.

A single-wire tramway constructed in Tennessee to bring logs from a plateau to a railroad in the valley had a $\frac{3}{4}$-inch main cable with a distance between terminals of 3700 feet. The grades conformed to the general slope of the land. The upper end of the cable was fastened to a tree on the edge of the plateau and ran in a straight line to a railroad located at the lower terminal in the valley. The cable was supported at intervals of from 150 to 250 feet on brackets of varying lengths which were fastened to trees. The cable rested, without fastening, in a slot in a casting bolted onto the end of the brackets, except in depressions where one end of a piece of strap iron was riveted to the outer side of the casting and the other end passed over the cable and was nailed to the bracket.

A log was carried by a pair of trolleys, each having two sheave pulleys which ran on the upper side of the cable. Two short chains each having a ring on one end and a "grab" on the other were used for attaching the logs to the trolleys.

Five sets of trolleys were joined together by a $\frac{3}{8}$-inch cable, which was wound around a drum equipped with a friction brake. This drum was placed at the head of the tramway and served both to control the speed of the descending load and to return the empty trolleys to the head of the tramway. Power for the latter purpose was supplied by a 15-horse-power gasoline engine.

The logs were loaded on the tramway from a set of balanced skids which were placed so that one end was directly under the main cable. Horses brought the logs to the base of the skids on which they were rolled. The grabs were then driven and the skids elevated until the rings on the grabs could be fastened in the hook on the trolleys.

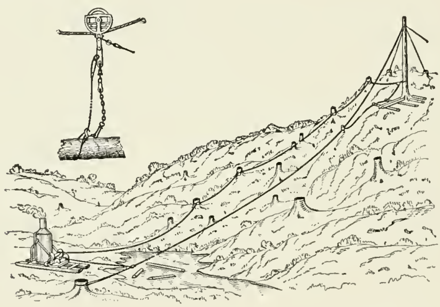
The maximum capacity of the tramway was 6000 feet log scale per turn, and approximately thirty minutes were consumed in making one round-trip.

A similar tramway has been used in the Northwest for getting logs upon plateaus from canyons. The cable is suspended between two points and the loaded trolleys are hauled to the top by a steam hoisting engine.

A special adaptation of a single-wire tramway[1] has been used on an operation in the Northwest for lowering logs on grades up to 60 degrees. The main cable was $1\frac{1}{8}$ inches in diameter and 1500 feet long. It was attached at the head of the tramway to a large tree at a height of 75 feet. The tree was braced securely on three sides with guy wires. A 16-inch sheave block was spliced to the lower end of the main cable and through this block a one-inch cable 150 feet long was passed. One end of the latter was attached to a stump and the other to the drum of a yarding engine, both stump and yarding engine being in front of and equidistant from the sheave block. The main cable could be lifted several feet above ground by tightening the secondary cable with a few turns on the drum. The logs were attached by

[1] See The Timberman, Portland, Oregon, August, 1909, p. 24.

chokers to a traveling block that ran on the main cable. The load descended by gravity, its speed being controlled by a $\frac{5}{8}$-inch trip line which was wound on a drum on the engine and then ran up the slope to the head of the tramway where it passed through a pulley fastened to a tree. The line was then attached to the rear of the traveling block. The trip line was held in position by several blocks placed at suitable intervals on the slope. This line also served to return the block to the head of the tramway. In case of a break in the machinery or of the load becoming unmanageable the main cable could be dropped to the ground and the load stopped.



Adapted from The Timberman.

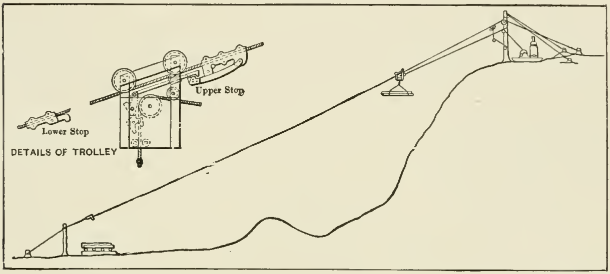
FIG. 60. — A Single-wire Tramway used in the Pacific Coast Forests. The details of the trolley and the method of attaching logs to it are shown in the enlarged cut.

A system of this character may be used for distances of 3000 feet when there are no pronounced elevations between the two ends of the tram.

Logs containing from 5000 to 6000 feet, log scale, have been successfully handled. The hourly capacity of this tramway was 12,000 feet, log scale, when the logs averaged from 300 to 500 feet, log scale. Three men were required to operate the tram.

A single-wire gravity tramway used in the West is described in The Timberman, April, 1912. A $1\frac{3}{8}$-inch main cable 2100 feet long is suspended between a tree on the upper slope and one

at the base of the grade, as shown in Fig. 61. Automatic trips are placed on the main cable at the loading and unloading points. The snubbing line which passes through a 2-sheave trolley has a ball near the free end which engages a catch in the trolley and serves to hold the load in position, and to trip it at the lower end. Power for returning the trolley to the head of the tram is furnished by a drum on a yarding engine at the head of the slope. A cable is fastened near the ends of a log that is to be transported. A hook on the end of the snubbing line is then caught in a ring midway between the ends of the cable and the log is hoisted into the air. When the ball on the snubbing line strikes the catch



Adapted from The Timberman.

Fig. 61. — A Single-cable Aerial Tramway in use in the Pacific Coast Forests.

in the trolley, the latter is freed from the stop at the head tree and with its load passes down the main cable by gravity, the speed being controlled by the yarding engine. On reaching the lower end of the cable the trolley is automatically tripped and the log lowered onto a skidway along a railroad. Poles 100 feet long, 27 inches in diameter at the butt and 1 foot in diameter at the top have been handled with ease. The average time required to traverse the distance from the head to the foot of the tramway is one and one-quarter minutes.

Another type of single-cable tramway has recently been patented. The chief features are a stationary track cable with intermediate supports, a continuous traction cable, a secondary

track cable also with intermediate supports, an engine with several drums for handling the cables and a series of trolleys which run on the main cable carrying the logs. The trolleys are returned to the head of the tramway on the secondary track cable.

It is designed to bring logs from a yarding engine to a loading device on a railroad at the lower terminus, as shown in Fig. 62. The main railroad extends under the tramway for a sufficient distance to receive the required number of empty cars. The framework supports the engine (25) which drives the drums (3), (4), (5) and (6). The end of the main track cable (7) passes over a sheave (not shown) which has a constant tension on it to prevent undue slack on the cable between intermediate supports when logs are traveling between them. The secondary track cable (8) is used for the return of the trolleys to the head of the tramway. The endless traction cable (9) passes over the drum (6) and is shown (10) passing to the upper end of the tramway where it is run through a sheave block and returned, between the intermediate supports, to the drum (6).

The tramway is operated as follows: With log (11) in the position shown, the operator releases the brake on drum (5) which permits the cable (12) to run out allowing the main cable to lower under its own weight, until it assumes the position shown by the dotted line (13). The log then rests on the car directly underneath it. The tongs (14) are then released from the log and the grips removed from the main cable which is at rest. The hooks (16) are then caught in the carriages (17) and elevated by means of the cable (18) and drum (4) and placed on the secondary cable (8). The grips are then connected with the traction cable (9) which is set in motion by the drum (6) and they are carried to the head of the tramway where they are again transferred to the main cable (7) by a similar device, a winch on the yarding engine being substituted for the drum (4). The main cable is lowered for the attachment of the tongs to the logs in the same manner as the cable is lowered for detaching the logs. When the log has been attached, the main cable is elevated and the grips attached to the traction cable (9). The drum (6) is

then revolved and the trolleys and log drawn to the lower end of the tramway. When car (19) is loaded, drum (3) is revolved and by means of cable (21) the train of cars is drawn to the left until car (22) is under the unloading device. When all the cars have been loaded they are pulled out by a locomotive and empties substituted for them.

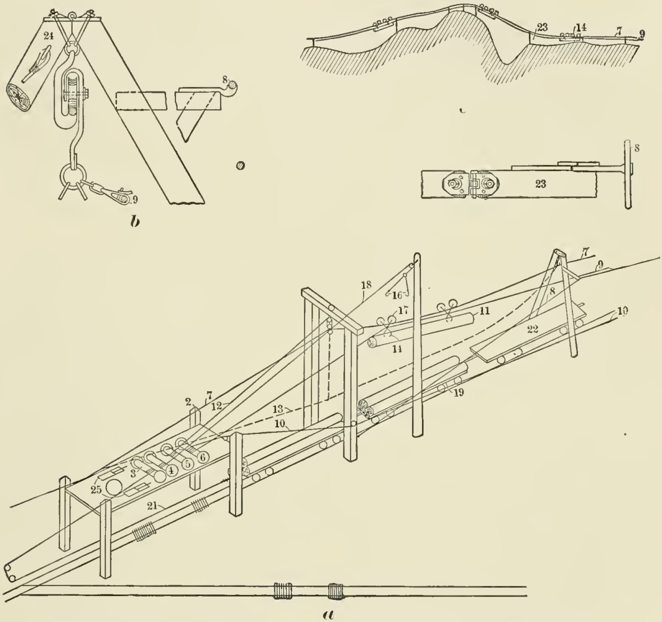


FIG. 62. — A Single-cable Tramway. *a*. Delivery station. *b*. Details of trolley. *c*. Profile of tramway line.

The details of the intermediate supports, trolleys and grips, also the method of hanging the main and secondary cable are shown in Fig. 62 *a*. The main cable is clamped securely to the hanger and serves to hold the supports upright, permitting

them to sway slightly as the loads travel along the cable. The supports are further braced by the cables (24).

The tramway is designed to carry a sufficient number of trolleys to keep a constant line of logs traveling toward the unloading end and empty trolleys traveling towards the upper end. The logs, however, should be spaced far enough apart so that at no time will two of them be suspended between a given set of intermediate supports.

A profile of the line of a tramway of this character is shown in Fig. 62*c*.

The above system is designed for ready removal from one site to another, the framework (2) being lowered on a flat car for transport. It is a modification of one known as the Bleichert[1] which is extensively employed for transporting timber, ores and other products in mountainous regions, in some cases for distances greater than 20 miles.

A second type, known as the endless cable tramway, has been employed for the transportation of shingle bolts. A tram of this character built in California had a $\frac{3}{4}$-inch main cable supported at frequent intervals on 16-inch sheave wheels attached to cross-arms fastened on heavy poles.

The cable was driven by a donkey engine geared to a 6-foot vertical drum around which the cable was wound several times and then passed out over the sheave blocks. About halfway between the two extremities the tramway turned a right angle, the cable passing around two loose drums at this point.

Shingle blocks were brought to temporary platforms by chutes and were attached by hand to the grips which were fixed at intervals along the cable. The bolts were tripped automatically at the terminus.

One hundred grips were operated on the line one-half of which were traveling loaded and the remainder returning empty to the loading point. The average output per hour for the tramway was thirty cords of bolts.

[1] Adolf Bleichert & Co., Leipzig and Wein. For a description of their system see Moderne Transportanlagen im Dienste der Holzgewinnung and Holzindustrie. Centralblatt für das gesamte Forstwesen, October, 1912, pp. 451–460.

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CHAPTER XVI

TIMBER SLIDES AND CHUTES

SLIDES are channels used chiefly for transporting logs, although pulpwood, crossties, firewood, etc., may be handled in this manner. There are two general types; namely, earth slides and timber slides, both of which are often combined to form a single slide.

They are in frequent use in Pennsylvania, the Appalachians, Idaho, Montana, the Northwest and, to a limited extent, in New England and New York.

Slides are built down the valleys of streams or down the slopes of mountains but they can seldom be constructed profitably across watersheds because the cost of spanning depressions is too great. They vary in length from a few hundred feet to several miles. They are chiefly employed in mountainous regions, although they are occasionally built in a flat country for transporting logs for short distances.

Earth Slides. — An earth or ground slide is used for short distances on steep grades where the soil is free from rocks and débris that would hinder the movement of logs. It is a furrow which is made by dragging logs over the proposed route. If the earth is easily stirred no previous preparation may be necessary, otherwise the soil must be loosened in places by a pick.

An improved form called the "trail slide," consists of a furrow made in a manner similar to a ground slide, with the addition of a continuous "fender" skid on the lower side of the trail. These skids are from 12 to 18 inches in diameter and are fastened together by a lap joint pierced with a 2-inch wooden pin, or with a ½-inch iron spike. The joint may or may not be supported on a cross-skid. Fender skids are kept in place by heavy stakes driven into the ground on the outer side. Slides

of this character are desirable on side-hills, where there is a tendency for the logs to leave an earth trail.

Timber Slides. — Timber slides consist of a trough or chute made of round or sawed timbers supported on cross-skids placed at frequent intervals. On low grades where logs will not run by gravity it is necessary to clear out a right-of-way 8 or 10 feet wide which serves both for the slide and as a pathway for the animals which handle the tow of logs. Where the grade is

Fig. 63. — View down a Timber Slide. Idaho.

sufficient to cause the logs to run by gravity, a right-of-way 4 feet wide is ample.

A common form of round timber slide consists of two parallel timbers supported on cross-skids placed from 8 to 15 feet apart. The timbers are from 9 inches to 18 inches in diameter and from 20 feet to 60 feet long and are cut from trees having a minimum taper. Either a log 6 inches or 8 inches in diameter with a hewed face or a 4-inch by 8-inch plank is often placed between the two slide timbers and fastened to the cross-skids. The poles are placed from 4 inches to 6 inches apart at their nearest point

on a two-pole slide and from 8 inches to 15 inches apart when the third pole is used. The timbers are usually placed with their butts up grade because they sliver less; some, however, prefer them placed in the opposite manner. The timbers are joined together by a simple lap joint, and are sunk into a skid directly beneath them and fastened to it by $1\frac{1}{2}$-inch or 2-inch hardwood treenails, or $\frac{1}{2}$-inch by 12-inch iron spikes. In order to strengthen the slide the joints are always broken.

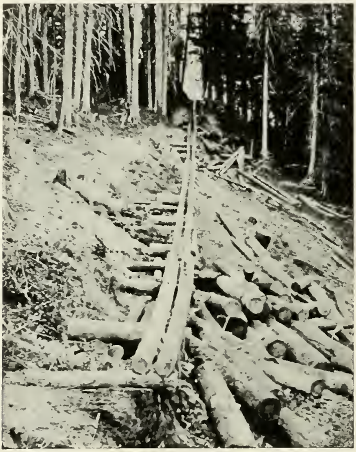

Fig. 64. — The Terminus of a Log Slide. Idaho.

On level stretches a slide is built on the ground and requires a minimum of bracing and support, while on steep pitches and in crossing depressions it is supported on crib work and is thoroughly braced because rigidity is important.

When the round logs are in place and securely fastened to the cross-skids, men are set to work to hew the inner faces of the slide timbers. This is particular work because any irregularities on the face of the slide will cause logs to jump. The scoring line is laid off with a chalk line and the timbers then scored with a felling ax and finally hewed smooth with a broadax.

A common method of dumping logs from a slide is to build one side several inches lower than the other. Another method used where there are several dumping grounds is to hew down the side of the slide on the dump side and place a switch called a "whippoorwill" diagonally across the slide timbers.

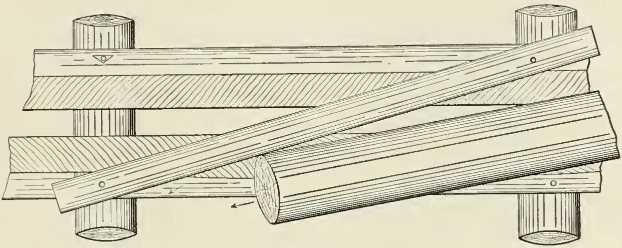

FIG. 65.—A Whippoorwill Switch used for throwing Logs from a Slide.

The lower part of the slide ends at a landing, where the grade should be level or slightly ascending to check the speed of the logs. When the log strikes the switch it is shunted off. When it is desired to send logs past a given dump the upper end of the switch is removed and placed across the depression on the slide timber and fastened by two heavy treenails.

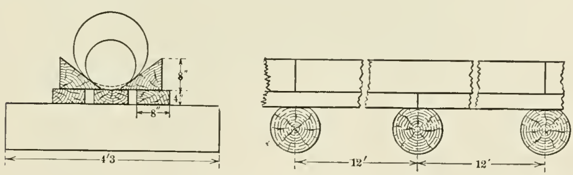

FIG. 66.—A Sawed Timber Slide, sometimes used where the Wear is Excessive.

The life of a pole slide is from six to ten years, when kept in repair.

Slides which are near a sawmill and subject to constant use are preferably made from sawed timbers.

On the Pacific Coast slides called "fore-and-aft" roads or "pole chutes" are used for trailing logs from yarding engines

to a landing, when power for moving the logs is provided by a road engine.

A fore-and-aft road consists of a trough from two to five poles wide, made from long straight timber with a minimum diameter of 10 inches. The ends of the poles are beveled, fitted together and drift-bolted to skids placed transversely under them at intervals of from 10 to 15 feet, thus providing a stable foundation.

Fig. 67.—A Fore-and-aft or Pole Road used with a Road Engine. Pacific Coast.

Side braces placed at intervals of 15 or 20 feet prevent the poles from spreading. The slide follows the ground level except where it crosses deep depressions or streams, when it is supported on cribwork. The roads are built as straight as possible to decrease the loss of engine power through friction.

A fore-and-aft road requires from 90,000 to 120,000 feet of timber per mile according to the amount of cribbing necessary.

Chutes are also employed on the Pacific Coast as the terminus of a skid or pole road, where the logs are dumped into a stream, pond or other body of water. These chutes consist of three

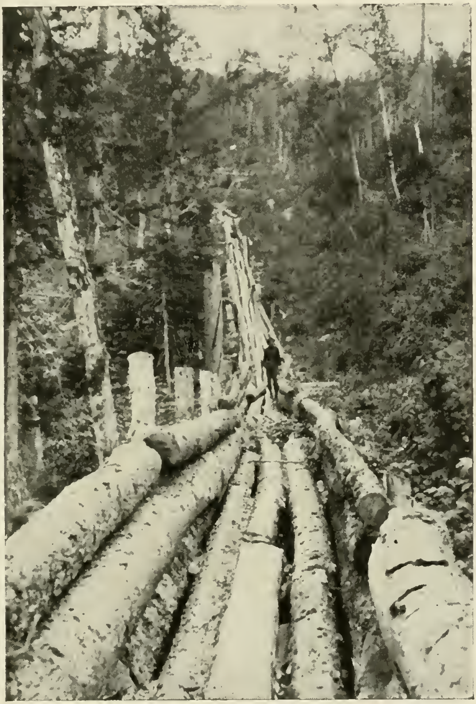

FIG. 68. — A Timber Chute. New Hampshire.

different parts; namely, the head which is cross-skidded like a skid road, the "slip" or chute proper and the "apron" or terminus. The cross-skids at the head offer less friction than a pole chute and enable the logs to be started readily. The poles in the chute proper are drift-bolted to heavy cross-stringers set

at 10-foot intervals on the upper part, and closer together near the base where the strain is greatest. Side poles serve as fenders to keep the logs in the chute. The apron extends out over the water in order to prevent the logs from striking bottom and is nearly parallel to the surface. The change in gradient from the slip to the apron must be gradual or the impact of the logs against the latter will soon destroy it. Chutes are used only when no other means of transport is feasible; for even under the most favorable operating conditions many logs are broken or damaged.

In the Northeast chutes similar to the one shown in Fig. 68 are occasionally built for bringing logs down steep slopes.

Another form of rough chute used in the same region is built as follows: A strip 5 or 6 feet wide is cleared down the slope. Logs are then snaked to a skidway at the head of the cleared strip, ready to be sent down by gravity. The first logs that go down are used to form a crude trough of parallel logs down which the bulk of the timber passes. Chutes of this character work best after a heavy frost or light snowfall.

In parts of the Appalachian region the logs are frequently brought down the beds of the mountain streams. Where the grades are steep and the bottom is smooth, little preparation is needed, but where the bed is rough, poles are laid lengthwise in the stream. The logs are started at the head of a cove and pass down the slide with great rapidity, collecting in a rough-and-tumble skidway at its base. Although timber is often damaged by breakage this is offset by the cheapness of transportation.

GRADES

The grade is an important feature of all slides. On trailing slides the grades are so low that logs will not run by gravity, and animal or other power is required to keep them in motion. Running slides have a grade sufficient in height to permit the transport of logs by gravity.

Slides vary in gradient at different points along the line and in some parts may be trailing slides and in other sections running

slides. The grade necessary to make logs run by gravity depends on the character and condition of the slide, the kind and size of the timber and whether the slide is used dry, greased or iced. The greater the weight of the log the faster its speed, hence large or long logs will run on lower grades than small or short ones. Heavy hardwood logs will run on lower grades than most soft-woods, and peeled logs will run on lower grades than if unpeeled.

Earth slides with a 25 per cent grade may be used during the summer but if the grade is as low as 10 per cent they are used to best advantage during cold weather when they can be iced.

During the warm season, horses are often used to drag logs in earth slides. Several logs are fastened together by grabs into a "turn" and a team is attached to the forward log. In cold weather animals can be wholly or partially dispensed with.

Iced timber slides are most efficient and therefore may be used on the lowest grades; those lubricated with skid grease rank next, while dry timber slides are the least efficient.

The following table of grades for running timber slides is from European practice:[1]

Material transported.	Per cent of grade.	
	Dry slide.	Ice slide.
Firewood	20–35	6–12
Crossties	30	....
Logs	15–20	3– 6

Grades of 25 per cent are considered best for dry running timber slides in which large logs are to be handled, although 45 per cent may be used on short stretches if the slide is built strong and rigid. The minimum grade should not be less than 10 per cent.

Timber slides with maximum grades of 80 per cent and an average grade of 60 per cent have been operated, but are not desirable because of the heavy loss through breakage.

[1] From Forest Utilization, by Karl Gayer. (Vol. V, "Schlich's Manual of Forestry," p. 325.)

CURVES

Curves on slides must be laid out with reference to the length of material to be handled. Sharp curves are always undesirable and especially so on steep pitches because the wear is excessive and logs are likely to jump out of the slide.

It is necessary on 2-pole and 3-pole slides to elevate the outer slide timber, the amount of elevation depending on the degree of curvature, the grade and the character of material that is being transported. A radius less than 200 feet is not desirable for any form of slide.

Fig. 69. — A Turn of Logs ready to move along a Trailing Slide.

OPERATION

Running slides are more expensive to operate than trailing slides because of the greater construction and maintenance expense, and the added cost of returning to the slide the logs which have jumped out of it.

Logs are usually rolled directly into slides either from large skidways on which many logs are stored when extensive runs are made, or from small skidways where the logs are sent down as they are yarded. In some cases skidways are dispensed with, the timbers being spread apart at the head of the slide and the logs dragged directly into it.

On running slides logs are sent down singly. Where a part or all of the slide is a trailing one from ten to forty logs are made up into a turn, but if there is a possibility of the logs running even for a short distance they are not fastened together.

In making up a turn on a trailing slide a log is rolled from the skidway into the slide, and is then hauled down a log length by a tow horse or team, so that the next log may be rolled in. Both are then moved ahead for another log length by attaching the tow line to the rear of the last log. The process is repeated until a turn is made up, when a team is attached to the rear end of the last log by a chain or rope from 30 feet to 50 feet long, to which is fastened an "L" hook, swamp hook, grab hook or "jay grab." The tow is then started for the landing. If the logs start to run in the slide the teamster can readily detach the hook and free the team which otherwise might be dragged down. The team drags the turn of logs to the landing, or until the grade becomes sufficient for the logs to run, whereupon the tow is started down the slide and the team returns to the head for more logs. The tow is picked up by another team on the first "dead" stretch and dragged to the next running portion of the slide.

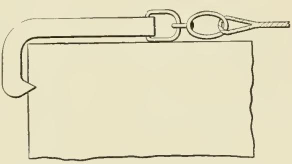

Fig. 70.—An "L" Hook used for Attaching the Tow Line to the Turn of Logs.

To reduce friction during the summer season the slow stretches of a slide are watered, or are greased with a cheap form of skid grease or crude petroleum. During the cold season such stretches are iced by throwing water on them at night. If the stretch is short and the water is close at hand it may be poured on with a bucket, otherwise a barrel is used in which two holes are

bored in one end, one over each slide stick. The barrel is then filled with water and lowered down the slide during the night.

On steep slopes where logs run fast and are apt to leave the slide, several devices are used to check the speed. A common method is by the use of a "goose-neck" or "scotch" made from 1½-inch or 2-inch round or square iron fashioned as shown in Fig. 71, *a* and *b*. They are placed in holes bored through the slide timbers and as the logs pass over them, the prongs bite into the wood and retard the progress. Logs will leave the slide unless the goose-necks are placed opposite each other. The holes in which the goose-necks are fitted are bored entirely through the

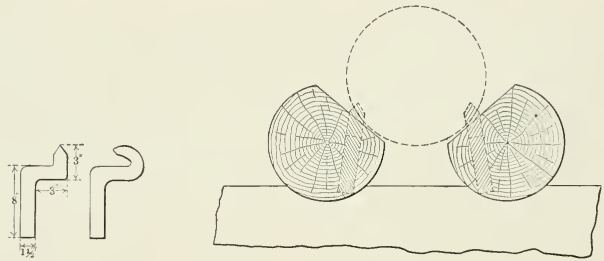

FIG. 71.—Goose-necks used for checking the Speed of Logs on Heavy Grades. *a* and *b* show two Common Forms. *c* shows the Manner of placing them in the Slide Timbers.

slide timbers so that dirt cannot accumulate in them. When not in use the goose-necks may be removed or dropped into notches cut into the slide timbers for that purpose.

Another form of brake consists of a log one end of which is pivoted to a framework erected above the slide. The free end is armed with spikes that drag on the logs as they pass under them.

Several slide tenders are required to keep slides greased and watered, adjust goose-necks and make repairs. As a general rule, several kinds and sizes of logs are run indiscriminately during the day, and it is necessary to use goose-necks on large logs and to remove them for the slower running small logs. Where logs have jumped out, laborers are required to return

them to the slide. This is done by building an improvised chute from the ground to the slide, and dragging the logs up with a team and tow line, or by rolling the logs up by hand on spiked skids. This work is done after the season's sliding has been completed.

COST

Slides vary greatly in cost depending on their character, the amount of cribbing required, the number of curves, the season of the year in which they are built and the efficiency of the labor.

Running slides are the most expensive form to construct, because they must be built stronger and more rigid than other forms. Curves require about one-third more labor to build than do straight stretches. Slides constructed during the winter cost about 25 per cent more to build than during warm weather and are often troublesome in the spring when the frost leaves the ground.

The cost per rod is approximately as follows: Earth slides, from 20 to 50 cents; 2-pole to 3-pole slides, from $3 to $5; plank slides, from $1.50 to $2; chutes on the Pacific Coast, from $8 to $10.

The cost per mile of operating a slide ranges from 50 cents to $1 per thousand feet log scale.

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CHAPTER XVII

FOREST RAILROADS

POLE ROADS

POLE roads were formerly used by lumbermen because the material for construction could be secured on the operation at no expense except for labor and stumpage but they are primitive in character and are now seldom used except on an occasional small operation where sawed wooden rails or steel rails cannot be secured at reasonable cost. Animals are used as draft power, although on down grades the cars may descend by gravity under control of a brakeman. Pole roads are seldom built for distances greater than from 2 to $2\frac{1}{2}$ miles.

A 25-foot right-of-way is required from which all brush must be removed and stumps grubbed out or cut level with the ground. The grade is then established. Turnouts for returning teams are provided at intervals of from $\frac{1}{4}$ to $\frac{1}{3}$ of a mile. On a track of this character, ascending grades greatly decrease the hauling ability of animals. The maximum grade for loaded cars hauled by two animals is 1.5 per cent. Where eight horses are used trams with 15 per cent ascending grades on the route to the woods and 3 per cent ascending grades for loaded cars en route to the mill have been used successfully.

The roads have a gauge of 5 or 6 feet, and the rails are long, straight poles from 9 to 12 inches in diameter, with as little taper as can be secured. The poles are hewed on the inner face to reduce friction on the wheel flange. They are laid with the butts all in one direction, the top of one pole being lap-jointed to the butt of the following one. Where the poles are not of the same size at the joint they are hewed down until the car wheels can pass over them readily.

On a hard bottom the poles are laid directly on the ground and are ballasted to make an even track. They are braced

at frequent intervals by stakes driven close to them on the outside. At curves where the track is liable to spread, braces are placed between the rails and also between the outer rail and trees or stumps. Cross-skids are used only on soft ground and are spaced from 6 to 8 feet apart. They are short round blocks placed under the rails but they do not extend across the track as

Photograph by H. R. McMillan.

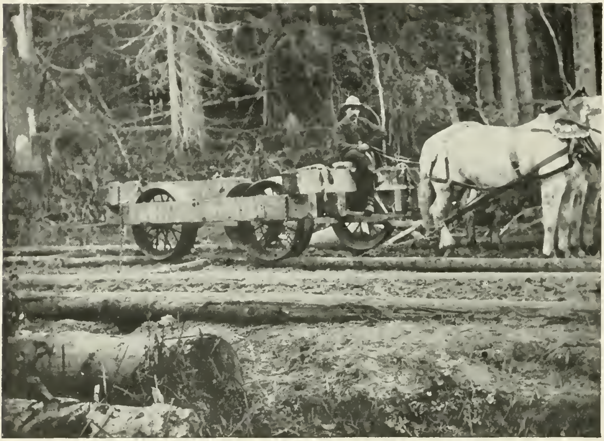
FIG. 72. — View down a Pole Tram-Road in Idaho.

they would interfere with the foothold of the draft animals. Poles are held together at the lap-joints and fastened to the cross-skids by means of wooden treenails from $1\frac{1}{2}$ to 2 inches in diameter, which are driven through the pole and skid into the ground.

A crew for building a pole road comprises six men and one team. Where the rails can be obtained along the right-of-way a crew will cut and peel the necessary poles and build 500 feet of

straight track daily. Curves require about one-third more labor than straight track. In Idaho the cost of the construction of 9 miles of pole road on rolling ground was $500 per mile, while on the Pacific Coast the cost has run as high as $1000 per mile.

The maintenance of a pole road is low. The chief item aside from the occasional replacement of a pole, consists in removing splinters from the rails, usually with a spade, and also greasing



Photograph by H. R. McMillan.

Fig. 73. — The Type of Car used on a Pole Road in Idaho.

the rails with skid grease. One man can care for two miles of track on half time.

The cars are built with a heavy framework of sawed timbers mounted on four wheels, each of which is about 42 inches in diameter with a slightly concave face, a 4-inch flange on the inner side and a 2-inch flange on the outer. Each wheel turns on a 2-inch fixed axle provided with a side play of 6 inches so that the wheels can adjust themselves to the inequalities of the rail and the uneven gauge.

The bunks are 10 feet long and from 10 to 12 feet apart. A reach which passes through the body of the car and projects $2\frac{1}{2}$ feet beyond the bunks serves as a point of attachment for the draft power.

Cars of this character drawn by two horses will carry 1400 feet log scale per load. A team will haul loaded cars from 8 to 10 miles daily.

On an Idaho pole tram $1\frac{1}{2}$ miles in length, two horses hauled from 7500 to 9000 feet log scale daily, each car load containing approximately 1600 feet. The cost of transport was about 85 cents per thousand feet.

On the Pacific Coast a team of eight horses hauled 20,000 feet daily on a $1\frac{1}{2}$-mile tram road, each car averaging 5000 feet.

Two horses are commonly used although on the Pacific Coast as many as eight are employed on some of the roads.

Light geared locomotives have been used to a limited extent but they are not adapted to this type of rail.

STRINGER ROADS

The stringer road soon superseded the pole road on operations where a sawmill was available for sawing rails.

The early stringer roads were operated by animal power; but light geared locomotives are now used almost exclusively except for stocking small mills.

Stringer roads have a greater capacity than pole roads and may be used to stock a single-band mill. They are employed chiefly on operations where suitable hardwoods are abundant for rails, where the operation is remote and the cost of transporting steel rails is excessive, where the length of haul is comparatively short and where the daily output is limited. Such conditions exist in the hardwood region of the Appalachians where this type of road is common.

The disadvantages of a stringer road as compared with steel railroads are that the rails become soft and wear out rapidly in rainy and wet weather; wheel flanges climb wooden rails more readily than steel; the cost of repairs and material for a year's

operation will largely meet the first cost of steel rails; and the road is about 75 per cent less efficient.

The right-of-way for a stringer road must be carefully graded, and crib bridges or trestles built where necessary. The grades should not exceed 3 per cent on the main line and 8 per cent on spurs. The preparation of the roadbed is as expensive as for a narrow-gauge steel road, the only saving effected being the original cost of rails.

FIG. 74.—A Stringer Road in the Appalachian Mountains.

A stringer road 3 or 4 miles in length is limited in capacity to 40,000 or 50,000 feet of logs per day.

The rails are 6 by 6 inches in size and are composed of two sawed pieces, each 3 by 6 inches, placed one on top of the other. The rails are fastened to the crossties and to each other by wire spikes. The top rail must be of some wood that will not splinter readily, such as beech and hard maple. Sometimes the rail is also covered with strap iron to prevent wear. The lower rail may be made of an inferior grade of timber such as wormy oak.

The rails are spiked to round crossties from 8 to 12 inches in diameter and 7 feet long, which are cut along the track and are spaced from 18 to 24 inches apart on main lines, and from 24 to 30 inches on spurs. The gauge is $3\frac{1}{2}$ or 4 feet.

The cost of maintenance of a stringer road in constant use is heavy because the rails sliver badly and break, requiring such frequent repairs after the first six months that the road will be practically rebuilt in two years.

The cost of constructing stringer roads, exclusive of the value of the timber used, ranges between $800 and $1200 per mile, but if many bridges are required the cost exceeds this.

Geared locomotives are used, the weights varying from twenty-five to thirty tons on main lines and from fifteen to seventeen tons on spurs. Larger ones are too heavy for a wooden track.

A light-weight, 2-truck, 8-wheel skeleton car is preferred for these roads. The wheels are 20 or 24 inches in diameter with a 6-inch tread which helps to keep them on the tracks where the gauge is too wide. Cars of this character, built for handling logs up to 20 feet in length, are from 22 to 24 feet long with bunks $7\frac{1}{2}$ or 8 feet wide, and are equipped with hand brakes. Each car weighs about two tons, has a rated capacity of from 15,000 to 20,000 pounds weight and usually carries from 1000 to 1200 feet of logs.

STEEL-RAIL ROADS

The successful use of steel-rail logging roads began in 1876, when Scott Gerrish, a logger in southern Michigan, built a railroad for transporting logs from Lake George to the Muskegon River down which they were driven to the mill. The number of logging railroads increased rapidly and in 1881 there were seventy-one in operation in Michigan and five in Wisconsin. In 1910 there were approximately 2000 logging railroads[1] with about 30,000 miles of track in operation in the United States.

Rail transport is gaining in favor in all sections of the country and with high stumpage values will become the preferred form of transport except where conditions are especially favorable for

[1] See The American Lumberman, Chicago, Illinois, March 19, 1910, p. 34.

floating and rafting. The only region in which their use is not extensive is in the New England States where water transportation has been the custom for years, due chiefly to the fact that many of the merchantable species will float, that the region is traversed by numerous streams and that trunk lines do not penetrate the forest regions to any extent.

Advantages of Railroad Transportation

(1) Accessibility. Railroads have made large areas of timber accessible which otherwise could not be logged because of the lack of streams for floating logs, or the absence of suitable manufacturing sites and shipping facilities on the natural water outlets.

(2) Independence of climatic conditions. Rail transport renders a logger practically free from climatic influences since he is not dependent on a snowfall to furnish a bottom for hauling, or on flood waters to float his logs. This enables him to operate throughout the year, with possible short interruptions due to heavy rainfall or snowfall.

(3) Market conditions. The use of railroad transport does not force the manufacturer to anticipate market conditions months in advance, because logs can be cut and hauled to the mill on short notice and special requirements for long timbers or for a heavy cut can be readily met. The plant can be closed during dull market periods without carrying on hand a large quantity of logs in the forest, subject to damage from fire, insects, and sapstain. The operator can turn over his money at frequent intervals and need not invest a large sum in advance in logging expenses.

(4) Utilization of hardwoods. The logger is able to bring out all species. This reduces logging expense, because of the heavier stand per acre secured.

(5) No loss of logs in transport.

(6) Clean logs. Rail transport lands the logs at their destination free from gravel, sand, iron and other foreign matter. A hardwood manufacturer operating on one of the large rivers estimates that clean logs can be manufactured 15 cents per thousand

cheaper because of the saving in saws, saw-filing expense and lost time on the part of sawmill labor. This saving is very appreciable in large plants. The value of some hardwoods, such as basswood for cooperage stock and birch for spool stock, is strongly influenced by the brightness of the wood, and even though such species can be floated their value is often reduced by exposure to weather and water.

Railroads for logging purposes can usually be constructed much cheaper than trunk roads because higher grades and sharper curves may be used and also because the roadbed need not always be placed in first-class condition to do satisfactory work. In a rough region, however, the initial expense is great and the cost may be prohibitive if many miles of road must be constructed to reach a tract. Under normal circumstances, railroads are chiefly adapted to large operations since the construction charge must be distributed over a large tonnage if the cost per thousand feet of timber handled is to be kept within reasonable limits.

CHOICE OF GAUGE

The choice of a narrow- or standard-gauge road for logging operations will be governed by the size of the operation, the topography, and the amount of capital available for investment. The final choice, however, should be governed not only by the initial cost of construction and equipment, but also by the cost of operation, because the increased construction cost of a standard-gauge may be more than compensated by a reduced operating charge

Narrow-gauge roads can be constructed cheaper than standard-gauge because (1) the width of cuts and fills is less; (2) sharper curves[1] are permissible because of the shorter wheel-base of locomotives and cars; (3) the cost of track laying is less per mile owing to the use of lighter rails and ties; (4) the initial expense for rolling stock and motive power is not so great.

[1] Curves as high as 50 degrees have been negotiated by narrow-gauge geared locomotives but a lower degree is desirable for efficient work.

There is little difference in the cost of trestles and other timber work for narrow- and standard-gauge roads. A narrow-gauge road is desirable for a limited output in a rough region because the cost may be one-third less than that of a standard-gauge. It therefore appeals to loggers with limited funds. It is also desirable in light or scattering stands where the track must be moved frequently. On soft bottom the track is easier to keep in operating condition owing to the lighter equipment used and the smaller loads hauled.

Where a large tonnage is handled, standard-gauge roads are more economical to operate because larger locomotives and cars can be used and the cost of operation per thousand feet for wages, fuel, oil and repairs for the heavier locomotives and cars will be less because of increased hauling capacity.

Standard-gauge is also desirable because trunk-line cars may be operated over the logging road. This is a great advantage where logs, pulpwood, tanbark and other forest products are to be shipped to outside points, since cars can be loaded in the forest and hauled to destination without reloading.

RIGHTS-OF-WAY

The right of loggers to build railroads across the lands of others is not recognized by the courts except where the roads have been chartered by the State. In the latter case the right of Eminent Domain is granted, and a line can be forced across foreign holdings by condemnation proceedings and the payment of just compensation to the owner.

Many logging roads are not incorporated because the route frequently does not tap a section in which any tonnage, other than that of the owners, will originate. Further the incorporation of the road subjects it to regulations governing the hours of labor for train crews, use of air brakes, height of draw bars on the equipment, filing of tariffs, and the submission of reports to the State Railroad Commission.

Chartered roads must be prepared to handle freight and passenger traffic, and many logging companies do not feel justified in maintaining the necessary equipment for this purpose,

especially since the handling of outside traffic at times interferes with the operation of logging trains.

Where the owner of a non-chartered road desires a right-of-way across the property of another the land may be bought at private sale, although this course is seldom desirable unless the road is ultimately to become a "common carrier," inasmuch as a narrow strip of property is of little value to the owner and is difficult to sell at the conclusion of logging operations. The more frequent practice is to lease[1] land for right-of-way for a period sufficient to permit the removal of timber. Such leases can usually be secured on terms satisfactory to all parties, although exorbitant rental is sometimes demanded, where the topography compels the location of the road within restricted limits, such as in a narrow valley.

Where timber rights are purchased without the fee to the land, the contract of sale should specify that the purchaser has the right to construct such roads as are necessary to secure the timber. Even if such a stipulation is not made, some courts[2] have ruled that a sale, or grant of standing trees implies a right of access and the use of the land for the purpose of cutting the timber and afterwards removing the logs. Unless some specific date is mentioned on which these rights terminate, the buyer is entitled to a "reasonable time" for removal. In case of litigation the length of time covered by the contract is decided by the courts after consideration of the specific case.

LOCATION

The location of the main line of a logging railroad is of great importance, for the engineer must preserve a proper balance between the cost of construction and the maintenance and operating charges. He must choose between an expensive roadbed with low grades and easy curves, or a cheaper roadbed with increased maintenance and operating expenses.

[1] In many places in the South $50 is considered a reasonable fee for the privilege of crossing a "forty."

[2] See a decision of the Supreme Court of Tennessee. Carson vs. Three States Lumber Company (Tenn.), 69 Southwestern Reporter, 320. 1902.

(1) Roads in a rolling or rough region should enter the tract at the lowest point and follow natural drainage, because it usually affords the best grade out of the region and the operator can bring his timber to the main line on a down grade. Roadbeds along natural drainage should be placed above high-water mark when possible, although on roads which are to be used only for a short period, it may be cheaper to build near the stream and suffer a few washouts rather than incur a very heavy construction expense.

(2) The shortest possible route is usually desirable, but it is better to increase the length of line if heavy cuts, fills, bridge and trestle construction can be avoided.

(3) "Velocity" grades are often used to advantage in crossing "draws" or depressions but they are feasible only on straight track, for it is extremely dangerous to run trains at high speed on a curved track which has a descending grade. In addition to their influence on the hauling ability of a locomotive, steep pitches are a disadvantage on a road because the track tends to work towards the lower levels and not only is the expense of maintenance greater than for a fairly level road but also the danger of wrecks is increased.

(4) Where logging railroads cross ridges or cover sharp changes in grade in a short distance, "switch backs" are usually preferable to doubling back with a curve since the latter method often necessitates a heavier construction expense. Switch backs often are the only means at hand for securing timber from elevations above or below the main line.

(5) Grades should not exceed 3 per cent and curves should not exceed 12 degrees on roads that are to be used for several years and over which a large amount of timber is to be hauled, although in a rough region these figures are often increased in practice.

Location in a region without marked topographical relief, such as the flat pineries or the cypress swamps of the South, presents no special difficulties. The main object is to bring the railroad to the timber by the shortest and cheapest route. The construction cost is low on dry lands in these regions, because only

limited quantities of material, chiefly earth, must be moved to make the roadbed. Where swamps are crossed piling is frequently used and numerous bridges or trestles may be required, but even here the cost per mile is less than the average in a mountainous region.

In the flat and gently rolling regions of the South the main lines are usually located by the woods foreman, although in many cases, engineers could be employed to advantage.

In a rolling or rough country, especially, in the West, location presents difficult problems, because roads must be confined chiefly to natural drainage and often the only means of access to timber is over a route requiring heavy cuts and fills and expensive bridge and trestle construction. The location of logging railroads in a rough region should be done by a location engineer who is an expert logger. Good railroad engineers without logging experience, are usually a failure at logging railroad work because they are not able to subordinate some of their ideals regarding standard railroad construction to the demands of practical logging.

Some companies have sufficient work to furnish continuous employment for logging engineers while others secure their services only when needed. Competent men for work of this character can be secured for from $175 to $250 per month.

Spur lines are located with less care than the main lines for they are shorter and of cheaper construction, since they are to be used only for a short period and a limited amount of timber is to come out over them. They should follow natural drainage in order to provide a down-haul for animal logging, but if power skidders are employed the roads may be placed on high ground and the logs dragged up grade, as it is often cheaper to construct and maintain a road on the higher ground, the skidding machine will bring logs up grade as easily as down, and the logs do not acquire momentum and foul the cable, or catch so readily behind stumps or débris.

In fairly level regions, where animals are used for logging, spurs are preferably located so that the maximum haul from any part of the operation will not exceed one-fourth mile, except for

small isolated tracts, which do not warrant the expense of building a railroad to them. Where a snaking system is used and the aim is to log all parts of the tract by this system, spurs should be placed approximately parallel to each other and 1800 or 2000 feet apart, for the maximum efficient radius of the machine does not exceed 1000 feet. In cypress and other forests where the area is logged by the cableway system, the spurs are placed parallel and from 1200 to 1400 feet apart. In mountainous sections, spur roads chiefly follow secondary drainage. On the Pacific Coast some operators build their spur roads to the yarding engines. A geared locomotive then drags the logs over the ties to the landing or the logs may be loaded on cars at the yarding engine and transported to destination. Where spur construction is costly the logs may be brought to the main line by road engines, animals, slides or flumes. In the Appalachian region spur construction is limited, and railroads are confined to the larger branches of the streams.

The grades and curves permissible on spurs are greater than on main lines because a slow speed is maintained, and lighter motive power is used. For the sake of efficiency and safety it is always desirable to keep grades and curves as low as possible, although short spurs may have grades as high as 6 per cent for loaded cars, and from 8 to 10 per cent for empty ones, and curves as high as 40 degrees.

Geared locomotives, only, are suitable for excessive grades and curves since the short wheel base permits the locomotive to make sharp turns, and because of the increased power secured through the gearing; on steep grades and sharp curves however, a geared locomotive can haul only a few cars at one time.

Methods of Location. — Topographic maps are now considered an essential part of the equipment of the modern logger operating in a rough region. These often are prepared in connection with the timber cruise, but if they are not available previous to railroad location, engineers prepare them, using contour intervals of 20 or 50 feet depending on the accuracy required and the roughness of the country. A successful engineer operating in Washington, on his reconnaissance survey preliminary to location, runs

out and blazes all section lines; determines distances by pacing, which are checked on quarter-section and section corners; and secures elevations by means of an aneroid barometer. A rough topographic map is prepared from this data and furnishes a basis for the preliminary location.

Having roughly determined the route of the road, the preliminary location follows. The engineer is aided in this work by one or two rod men and two or more axmen, depending on the density of brush along the route. Where an expensive road is to be built, engineers recommend the use of a transit in preliminary work, because of the accuracy demanded in final results. Some use a railroad compass and a hand level of the Abney type both for main lines and spurs. In a fairly level country the railroad compass will meet all needs, in fact some find a small staff compass ample.

The engineer having traveled over the proposed route one or more times and knowing the problems to be solved, locates a line of tangents and sets stakes marked with the station number, at 100-foot intervals along the right-of-way. As the line progresses, the engineer, by trial, selects the points which will keep his grades and curves within the limits set for the line. Several trial lines may be necessary to secure a satisfactory grade.

On spur lines in a rough region and on main lines in a fairly level region, the preliminary survey is dispensed with. A railroad compass or a box compass is often used in lieu of a transit, and in many sections the woods' foreman or superintendent replaces the engineer.

A common method in the pineries of the South is to locate a line of tangents by the use of three 6-foot straight pickets, along which the locator sights, placing center stakes at 100-foot intervals.

The final location of the line of tangents is followed by the location of curves. Loggers have a number of rule-of-thumb methods of locating curves, which, although inaccurate, are satisfactory for railroads where a high degree of engineering ability is not demanded. Many who use rule-of-thumb methods determine the deflection angle by eye and lay off trial curves,

persisting until they find one which will connect their two tangents. Three methods are in general use by logging engineers for laying out curves on logging roads; namely, the tangent-offset method, by distance scaled from a map, and by the use of a transit or compass.[1]

On main line work in a rough region, the location survey is followed by a line of levels which furnishes data for a profile map on which the "elevation of grade" is shown. This is preliminary to making an estimate of the cost of moving earth and rock. The cubic yardage is computed from cross sections[2] taken along the proposed grade at each station on level or fairly level ground, and at every point where there is a decided change in the configuration of the surface.

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[2] See "Earthwork and its Cost," by H. P. Gillette. McGraw-Hill Book Co., New York, 1912. pp. 175–182. "Highway Construction," by Austin T. Byrne. John Wiley and Sons, N. Y., 1902. pp. 447–454. "Theory and Practice of Surveying," by J. B. Johnson. John Wiley and Sons, New York, 1901. pp. 438–471.

CHAPTER XVIII

RAILROAD CONSTRUCTION

The construction of the roadbed for a logging railroad usually precedes logging by a few weeks, although it may be several months or a year in advance. An advantage of the latter is that the roadbed has an opportunity to settle before the steel is laid and the road operated. This gives a more stable track and one that is cheaper to maintain. In regions subject to heavy rainfall and with earth that washes badly, this practice is not desirable since the roadbed will suffer through erosion.

CLEARING THE RIGHT-OF-WAY

Previous to starting the grading of the right-of-way, it is necessary to cut and remove the standing timber, brush and stumps which will interfere with the roadbed. This work is often done by contract at a stated price per acre, with or without an additional payment for all merchantable saw logs cut.

Main line rights-of-way are generally cut 100 feet wide in order to prevent the track from being covered with " down timber " during wind storms. On spur roads the right-of-way is usually from 18 to 50 feet wide. In the South, however, rights-of-way for spurs are often made 120 feet wide in order to provide skidway space on each side of the track. The right-of-way crew fells the timber, removes the stumps from the roadbed, if necessary, and cuts the brush from the skidway site. The timber adjacent to the roadbed is not felled until the surrounding area is logged, because insects seriously damage felled timber that remains in the forest during the warm months. Where the skidway sites are cleared off by the logging crew the cost is usually greater than by the method above mentioned both because of the enforced idleness of the teams and the low efficiency of team-

sters when performing swamping work which is usually distasteful to them.

The timber cut from a right-of-way may be used for saw logs, culverts, trestles, bridges, corduroy and for filling in low places to reduce the amount of earth required for fills. Material of merchantable value both from green and "dead-and-down" timber is cut into saw logs and either scattered or piled on skidways along the right-of-way outside of the grade line.

On main lines and spurs all stumps should be removed from the roadbed unless they are on the site of a proposed fill and will be covered with at least one foot of earth; or so located that they will not furnish a bearing for any part of the track; or the character of the ground is such that the removal of the stump during wet weather will cause a soft spot which cannot be kept up during the rainy period.

Where the stumps are to be covered with earth they are cut off near the ground. Those on the right-of-way outside of the roadbed may be cut at any convenient height. The removal of stumps is usually accomplished by blasting with powder or dynamite, by grubbing or by burning them out. The cost for the former ranges from 30 cents to several dollars per stump, and for grubbing from 6 to 8 cents for each inch of diameter. Small and medium-sized trees can best be removed by cutting all roots from 3 to 4 feet from the base of the tree and allowing the weight of the crown and bole to aid in pulling out the stump.

In the South clearing the main line right-of-way, including the grubbing of stumps on the roadbed, can usually be done by contract for $25 per acre. During 1910 a contract was let in northern Louisiana for a 100-foot right-of-way, at a price of $100 per mile. This included the felling of all timber and the cutting off at the ground of all stumps on the roadbed, but not their removal. The contractor received in addition, 50 cents per thousand feet for all merchantable material cut into saw logs. A 40-foot right-of-way in this region can usually be cleared and stumps on the roadbed removed for $90 per mile, and a 100-foot right-of-way for $150 per mile.

In the Pacific Northwest, clearing a 50-foot right-of-way costs from \$2 to \$12 per 100 feet, depending on the amount of brush, down timber and standing timber on the site and the difficulties of moving it. The average should not exceed \$500 per mile if the stumps are blasted and the timber is dragged from the right-of-way by a yarding engine.

Following the felling of the timber and the removal of stumps comes the construction of the roadbed. This covers the movement of earth and rock for cuts and fills, the construction of trestles, culverts, cribbing and other timber structures.

FILLS AND CUTS

Fills on a logging road should be 12 or 14 feet wide on top for a standard-gauge road and 10 or 12 feet wide for a narrow-gauge. The standard slope for an earthwork fill is $1\frac{1}{2} : 1$.[1] When the fill is made from rock, a 1 : 1 slope may be ample.

In cuts the roadbed must be wide enough to give room for a drainage ditch on either side. These will require about 3 additional feet each, and the cut should be about 16 feet at the base. In earth cuts the ratio of slope is $1\frac{1}{2} : 1$ and in solid rock cuts the walls are perpendicular or nearly so.

Main lines are graded up carefully, and suitable ditches maintained. Even on level sections it is desirable to elevate the track and put in ditches, because of the cheaper cost of maintenance during wet weather.

A form of main line spur track used in southern Arkansas is shown in Fig. 75, *a*.

The earth from the ditches is sufficient for ballasting the ties and the grade costs but little except for the ditches. The

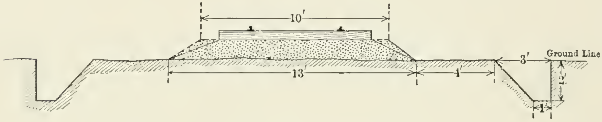
[1] The angle of repose or slope that a face of earth makes with the horizontal when not subjected to the elements is as follows:

Compact earth	50 degrees	or $\frac{3}{4}$ to 1
Clay, well drained	45 degrees	or 1 to 1
Gravel	40 degrees	or $1\frac{1}{4}$ to 1
Dry sand	38 degrees	or $1\frac{1}{4}$ to 1
Wet sand	22 degrees	or $2\frac{1}{2}$ to 1
Vegetable earth (loam)	28 degrees	or $1\frac{3}{4}$ to 1
Wet clay	16 degrees	or 3 to 1

average cost per 100 feet ranges from \$6 to \$7 for the type shown in Fig. 75, *a*, and from \$3 to \$4 for the one shown in Fig. 75, *b*.

On spurs a minimum of fill and cut work is done and ditching is not resorted to unless absolutely necessary.

Where fills of 2 or more feet are to be made on spur roads, it is a common practice to fill the bed of the grade with logs, if nonmerchantable timber is close at hand and to place a cover of earth over them to give a bearing for the ties. This practice



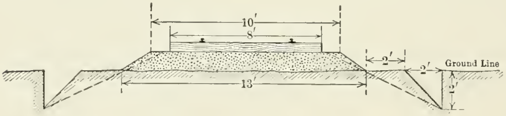


FIG. 75.—Two Methods of constructing a Grade for a Logging Railroad. *a*, main line spur. *b*, secondary spur. The ditch is cut to the dotted line when the track is surfaced.

cheapens the cost of construction, especially when earth for a fill must be taken from a "borrow" pit. This type of roadbed will last for at least one year.

The movement of earth and rock in the construction of cuts and fills is most frequently done by contract. The unit on which payment is based is the cubic yard, the material being measured "in place," that is, in the natural bank before it has been disturbed. It is customary to classify the material to be moved and to regulate the prices accordingly. The classification and quantity of material moved are determined by the supervising engineer.

The following standard classification is in extensive use:

(1) *Earth.* — Loam, sand, gravel or clay. Material that can be handled with a pick and shovel, or that can be plowed readily.

(2) *Hardpan.* — Very dense clays and gravels, cemented with iron oxide. Soft shales that are easily worked may also be included.

(3) *Loose Rock.* — Shales and other rock that can be quarried without blasting, although blasting may be resorted to occasionally.

(4) *Solid Rock.* — Material requiring blasting for removal.

The contract price per cubic yard for the removal of earth or rock usually includes excavating, hauling, and placing the material in a fill or a waste pit. It is not customary to pay for making a cut and also to pay for a fill made from the same material; in other words, payment for a given cubic yard is made but once. Grading contracts may have an "overhaul" clause which provides that for all earth hauled more than a specified distance ("free haul"), the contractor shall be paid a stated sum per cubic yard for each 100 feet of overhaul. On logging operations the length of free haul ranges from 100 to 500 feet.

The price paid for moving material varies greatly in different regions and is influenced by the length of haul, the kind of material moved, the character of classification, the degree of accuracy used in actual classification and the season of the year, the cost of winter work being about 25 per cent higher than that of work done during the summer.

The following prices were paid on logging railroad operations and represent general contract prices on work of this character. The average work on logging roads except on the Pacific Coast usually presents no special problems and can be performed with simple equipment which does not require a heavy financial outlay. Loggers are able, therefore, to contract with local men on favorable terms.

Class.	Alabama.			Louisiana.	Texas and Arkansas.	Washington.		
	Contract price.	Free haul.	Bonus for overhaul. Per 100 feet.	Contract price.[1]	Contract price.[1]	Contract price.	Free haul.	Bonus for overhaul. Per 100 feet.
	Cents.	Feet.	Cents.	Cents.	Cents.	Cents.	Feet.	Cents.
Earth......	25	300	0.05	0.14	0.16	16–20	100	0.05
Hardpan....	..	...	....	....	....	25	100	0.05
Loose rock..	35	300	0.05	....	....	35–45	100	0.05
Solid rock...	65	300	0.05	....	....	75–1.25	100	0.05

[1] No limit to free haul, but it was not great in any case.

MOVEMENT OF EARTH[1]

The movement of earth for road construction, railroad grades and trails may be performed in various ways among which the following are in general use:

(1) With pick and shovel, the earth being loosened by the pick and then thrown directly out of the cut.

(2) Loosening by pick or plow and transport on wheelbarrows, two-wheeled dump carts or dump wagons.

(3) Loosening by plow or by dynamite and transport on drag scrapers, wheel scrapers or dump cars with horse draft.

(4) Steam shovel lift and transport on dump cars or flat cars.

The first three methods are employed by owners of comparatively simple and inexpensive outfits. Steam shovels are seldom

[1] Earth of various kinds increases in bulk when disturbed for removal, as shown in the following table:

Character of material.	Increase in bulk.
	Per cent.
Earth, freshly loosened	14 to 50
Clean sand and gravel	14 to 15
Loam, loamy sand and gravel	20
Dense clay, dense mixtures of gravel and clay	33 to 50
Unusually dense gravel and clay banks	50

Shrinkage in volume of embankments is dependent on the method used to compact them. Loose earth with rainfall as the only compacting element will be about 8 per cent above normal at the expiration of a year. Earth compacted with two-wheeled carts or scrapers occupies from 5 to 10 per cent less space than it did "in place" and will shrink slightly more during the next few years.

employed except where a large amount of earth is to be moved and where a log loader that can be converted into a steam shovel is available.

Plowing. — Contractors usually assume that a team and driver, with a helper to hold the plow can loosen per hour, 25 cubic yards of fairly tough clay; 35 cubic yards of gravelly loam; or 50 cubic yards of loam. A pick-pointed plow drawn by four or six horses and with two men riding the plow beam, is required for breaking up tough clay or hardpan, the usual rate being from 15 to 20 cubic yards per hour. Thirty-five cubic yards of "average earth" per hour is considered satisfactory work.[1]

Pick Work. — The pick is used only for light work and in confined places. In one hour a man will loosen from 1.6 to 2.3 cubic yards of earth, from 0.7 to 1.1 cubic yards of gravel, or 0.9 cubic yards of hardpan.[1]

Picking and Shoveling. — Pick-loosened earth is nearly always handled with a shovel. This method of moving earth is of importance in forest work because most light railroad grades are constructed in this manner, and it is also used in trail building.

The following table[2] shows the average amount of cubic yardage picked and shoveled by one man per hour.

Material.	Capacity per man per hour.	Cost per cubic yard.[1]	Authority.
	Cubic yards.	Cents.	
Hardpan (clay and gravel)	0.4	37½	M. Ancelin
Common earth	0.8–1.2	19–12½	"
Hardpan	0.33	45½	Cole
Clay (stiff)	0.85	17½	"
Clay	1.00	15	"
Sand	1.25	12	"
Sandy soil	0.8–1.2	19–12½	Gillette
Clayey earth	1.3	12	"
Clay, fairly tough	0.9	17	"
Sandy soil, frozen	0.75	20	"
Gravel or clay	0.7–0.8	20	Billings
Earth	1.1–1.2	13–14	Hogdson

[1] Wages 15 cents per hour.

[1] The data on output are taken from "Earthwork and Its Cost," by H. P. Gillette. McGraw-Hill Book Company, New York, 1912.

[2] From "Earthwork and its Cost," by H. P. Gillette. McGraw-Hill Book Company, New York, 1912. P. 23.

The hourly output per man shoveling average soil is 1.4 cubic yards, but this may be increased to 2 cubic yards under efficient supervision.

With Dynamite. — A logging operator in Mississippi describes[1] a method of making cuts in gumbo 5 feet or less in depth when the earth is to be "wasted." The reported cost was 50 per cent less than with the usual methods of moving earth.

Holes of the required depth and 20 inches apart were made with a round, sharpened bar. The outside row of holes had a degree of slant that would produce a cut with sides of the desired slope. After covering the site of the proposed cut with holes, they were loaded with 60 per cent dynamite. The center holes were loaded heavier than the others and were primed for electric firing. The explosion of the central charges fired the others. The length of cut blasted at one time did not exceed 200 feet. A large amount of the earth was thrown entirely out of the cut and the remainder was handled readily with a drag scraper. In tight wet earth one ton of 60 per cent dynamite will loosen earth for 1600 linear feet, where the maximum cut is 5 feet.

Wheelbarrows. — Barrows are not profitable for moving earth except on short hauls, for stony soil, and in places unfavorable for the use of horses. The average load on level runs is approximately 250 pounds or $\frac{1}{10}$ of a cubic yard of earth, and on fairly steep grades $\frac{1}{15}$ of a cubic yard, "place measure."

The average amounts moved, per barrow, on a level in ten hours and the cost per cubic yard for picking, shoveling and moving, when wages are 15 cents per hour, are as follows:[2]

Distance.	Quantity.	Cost per cubic yard.
Feet.	Cubic yards.	Cents.
100	10.5	22.50
75	11.1	21.25
50	11.8	20.00
25	12.5	18.75

[1] See American Lumberman, Chicago, Illinois, July 15, 1911, p. 50.

[2] The figures on the amount of work performed and costs are based on data contained in "Earthwork and its Cost," by H. P. Gillette. McGraw-Hill Book Company, New York, 1912.

Two-wheeled Dump Carts. — These are used for transporting material for distances varying from 75 to 500 feet, and are especially serviceable on short hauls and in narrow cuts.

The average load of dump carts on level roads is 0.37 cubic yards, and on steep ascents 0.25 cubic yards, "place measure."

On short hauls one driver attends two carts, leading one to the dump while the other is being loaded. On long hauls he may handle two carts by taking both at one time. The carts are loaded at the pit by shovelmen.

When wages are 15 cents, and horse hire 10 cents per hour the average day's work on level ground for a one-horse cart of $\frac{1}{3}$ cubic yard capacity, and the cost per cubic yard for plowing, shoveling and hauling average earth are as follows: [1]

Distance.	Quantity.	Cost per cubic yard.
Feet.	Cubic yards.	Cents.
100	40.0	20.25
200	33.3	21.50
300	28.5	22.75
400	25.0	24.00

Dump Wagons. — Where a wagon is used, a flat-bottom, two-horse type is preferred, which usually has the following capacity:

Character of road.	Capacity.
	Cubic yards.
Very poor earth road	0.8
Poor earth road	1.0
Good hard earth road	1.6

An average team will travel 20 miles per day on fairly hard earth roads, that is, 10 miles loaded and 10 miles without a load. On poor roads and soft ground 15 miles is the maximum distance. These rates of travel include occasional stops for rests.

When wages are 15 cents and horse hire 10 cents per hour,

[1] The figures on the amount of work performed and costs are based on data contained in "Earthwork and its Cost," by H. P. Gillette. McGraw-Hill Book Company, New York, 1912.

the cost per cubic yard, and the average amounts of earth moved daily are as follows:[1]

Distance.	Quantity.	Cost per cubic yard.
Feet.	Cubic yards.	Cents.
300	75	20.1
400	..	20.8
500	..	21.5
600	..	22.2
800	50	23.6
1000	34	25.0
2000	26	32.0
3000	..	39.0
4000	..	46.0
5000	..	53.0

Drag Scrapers. — A drag scraper is a steel scoop used for moving earth for short distances. It is the preferable form for stony ground and for soils filled with roots. It is drawn by two horses.

The No. 2 scraper, weighing about 100 pounds, is the one commonly used, and costs from $10 to $15. Its actual capacity, "place measure," is $\frac{1}{10}$ of a cubic yard of tough clay; $\frac{1}{7}$ cubic yard of gravel; or $\frac{1}{5}$ cubic yard of loam.

Drag scrapers work in units of three on short hauls, the teams traveling about 50 feet apart in an ellipse. They are loaded by an extra man as they pass the pit and are dumped by the teamsters.

On a 50-foot haul the average ten-hour output for a drag scraper is 62 cubic yards of earth and gravel, and 40 cubic yards of stiff clay. The cost per cubic yard of handling average earth is approximately 9 cents for a 50-foot, and 10 cents for a 100-foot, haul.[1] Earth for scraper work is loosened with a plow or by dynamite.

Wheel Scrapers. — The wheel scraper consists of a steel scoop hung low between two wheels. The following sizes are in common use:

[1] The figures on the amount of work performed and costs are based on data contained in "Earthwork and its Cost," by H. P. Gillette. McGraw-Hill Book Company, New York, 1912.

Number 1 wheelers are used for short hauls and steep rises and should replace drag scrapers under these conditions except where the soil is rocky or full of roots. Snatch teams are required for loading No. 2 and larger scrapers, and even then it is impossible to fill the bowl in tough clay. Shovels must be used for this purpose.

	Weight.	Actual capacity[1], "place measure."
	Pounds.	Cubic yards.
No. 1.........	340 to 450	$\frac{1}{5}$
No. 2.........	475 to 500	$\frac{1}{4}$
No. $2\frac{1}{2}$........	575	$\frac{1}{3}$
No. 3.........	625 to 800	$\frac{4}{10}$

[1] When the bowl is level full of earth.

When wages are 15 cents and horse hire 10 cents per hour the cost per cubic yard and the amount of earth moved daily with a No. 1 scraper is approximately as follows:[1]

Distance.	Quantity.	Cost per cubic yard.
Feet.	Cubic yards.	Cents.
100	48.0	8.75
200	34.0	11.50
300	26.6	14.25
400	22.0	17.00
600	16.0	22.50

Cars with Animal Draft. — Horse-drawn dump cars, ranging in capacity from 1 to 3 cubic yards, may be advantageously employed where large quantities of earth are to be moved for a distance of several hundred feet. They are generally run on 16 or 20-pound steel rails, with 6 by 6-inch by 5-foot unballasted ties spaced about 4 feet, center to center. The cost of laying such a track averages $100 per mile, exclusive of the value of the material.

A dump car with a capacity of 2 cubic yards weighs about

[1] The figures on the amount of work performed and costs are based on data contained in "Earthwork and its Cost," by H. P. Gillette. McGraw-Hill Book Company, New York, 1912.

one ton and holds about 5400 pounds of earth. A horse can pull a loaded car on a level all day, and can go up 4 per cent grades occasionally, if frequent rests are given. The hauling ability of heavy horses pulling cars up different grades is approximately as follows:

Grade.	One horse.	Two horses.
	Cubic yards.	Cubic yards.
Level.........	2.00	5.0
1 per cent.....	1.10	3.0
2 per cent.....	0.64	2.0
3 per cent.....	0.37	1.5
4 per cent.....	0.18	0.75 to 1.10

When wages are 15 cents and horse hire 10 cents per hour a 2-cubic-yard dump car drawn by one horse will move approximately the following yardage daily:

Distance.	Quantity.	Cost per cubic yard.
Feet.	Cubic yards.	Cents.
1000	85 to 90	0.17
2000	60 to 65	0.18
3000	35 to 40	0.19
4000	20 to 25	0.20

The cars are loaded by shovelers, each handling from 15 to 18 cubic yards daily.[1]

Steam Shovels. — Steam shovels are occasionally used on logging railroad work where large cuts are to be made or heavy ditching work done. "American" log loaders are offered on the market with a steam shovel attachment so that the loader can be converted into a shovel when desired. The dipper used has a capacity of approximately $\frac{9}{16}$ of a cubic yard, and under favorable circumstances from 50 to 60 cubic yards per hour can be moved. Regular steam shovel work costs from 9 cents per cubic yard upward.

[1] The figures on the amount of work performed and costs are based on data contained in "Earthwork and its Cost," by H. P. Gillette. McGraw-Hill Book Company. New York, 1912.

ROCK EXCAVATION

Previous to excavation rock is broken by an explosive into fragments that can be handled readily.

It is transported chiefly in carts, wagons and cars, although it may be moved for short distances on wheelbarrows or thrown out by hand in shallow cuts.

A cubic yard, place measure, of rock increases from 60 to 80 per cent when broken up. On an average only 60 per cent as much yardage of rock can be hauled as of earth.

Payment for the removal of rock which is classified as "loose rock" and "solid rock" is on the basis of the cubic yard, "in place."

A. BLASTING

The holes in which charges are placed are usually bored with hand drills. The diameter and spacing of holes depend upon the kind of explosive used, the character of the rock and the method of handling it. As a rule, the holes are spaced a distance apart equal to their depth, although in hard rock they are often placed closer together. Close spacing increases the amount of drill work required and the quantity of explosive used, although it is often more economical because of the smaller size of material, which makes handling cheaper.

Drilling. — Hand drilling is preferred for logging work because of the limited amount of rock moved and the difficulties of transporting drilling machinery and equipment to the site of the work.

There are three forms of drills used for hand work; namely, the "churn drill," the "jumper drill" and the "hand drill."

Churn Drill. — This is the most economical form of drill for holes up to 30 feet in depth and from $1\frac{1}{2}$ to $2\frac{1}{2}$ inches in diameter.

The drill consists of a $1\frac{1}{4}$- or $1\frac{1}{2}$-inch round iron bar of the required length, on one end of which is welded a steel chisel bit from 30 to 100 per cent wider than the diameter of the rod. Several rods of different lengths are required for drilling a deep hole.

The drill is operated by raising it from 18 to 24 inches and allowing it to drop, the weight of the drill furnishing the power.

One man can operate a drill for holes 3 feet or under in depth, two men for those of medium depth and three or four men for the deepest holes.

Trautwine gives the following as an average ten hours' work for a churn drill:

Character of rock.	Diameter of hole.	Depth of hole.
	Inches.	Feet.
Hard gneiss, granite or silicious limestone	$1\frac{3}{4}$	7 to 8
Tough compact hornblende	$1\frac{3}{4}$	5 to 7
Solid quartz	$1\frac{3}{4}$	3 to 5
Ordinary limestone	$1\frac{3}{8}$	8 to 9
Sandstone	$1\frac{3}{8}$	9 to 10

Jumper Drill. — These are shorter than churn drills and are operated by two or more men, one of whom sitting down holds the drill and revolves it about $\frac{1}{8}$ of a revolution after each stroke, while the other men strike the drill head with 8- or 12-pound sledge hammers.

The drill rods are of $\frac{7}{8}$-inch octagon steel and the bits are $1\frac{1}{4}$ or $1\frac{1}{2}$ inches wide. The maximum depth for efficient work with a three-man jumper drill ranges between 6 and 8 feet.

Since it can be held on the exact spot, this drill can be used for smaller holes than a churn drill. It is also best for conglomerate rock, because it is not so easily deflected by pebbles.

The amount of work performed in ten hours by three men, one holder and two strikers, using a jumper is approximately as follows for 6-foot holes:[1]

Character of rock.	Feet.
Granite	7
Trap (basalt)	11
Limestone	16

Hand Drill. — The hand drilling method is similar to jump drilling, except that the operator sitting down holds the drill with

[1] From "Handbook of Cost Data," by H. B. Gillette. Myron C. Clark Publishing Co., Chicago, Ill., 1910. P. 185.

one hand and strikes the drill with a 2- or $4\frac{1}{2}$-pound hammer held in the other hand. These are used only for holes of small diameter, 3 feet or less in depth. This drill may be used for horizontal or inclined bores.

Hand drill rods are made of octagon steel and range in size from $\frac{5}{8}$ of an inch in diameter, with a $\frac{3}{4}$- or 1-inch bit, up to a $\frac{7}{8}$-inch rod with a $1\frac{1}{4}$-inch bit. A 1-inch drill rod is the maximum size practicable. Chisel-shaped bits, similar to those for jumper and churn drills, are used.

B. EXPLOSIVES[1]

Explosives for blasting belong to two general classes:

1. High explosives which require for explosion an intermediate agent, such as a fulminate detonator.
2. Low explosives which can be fired by direct ignition.

High Explosives. — For blasting purposes these are marketed in the form of dynamite, giant powder, gelatine, and some other similar products. The more powerful forms are composed of a mixture of nitro-glycerine and some absorbent, such as sawdust and wood pulp, while the lower grades contain explosive salts in addition. Nitro-glycerine undergoes no change when combined with the absorbent, the latter acting only as a cushion and as a means of solidifying the liquid.

High explosives are made of varying strengths and are graded on the percentage of nitro-glycerine they contain. The standard grades range from 75 per cent down. Those most frequently used are 40 and 60 per cent, the former being preferred for many classes of work.

High-grade dynamite explodes with great suddenness and will shatter rocks and stumps into small fragments. It is especially suitable for very hard rock or where small drill holes are necessary. Medium grades are best for soft rock because their explosive force is not so violent and sudden, and the tendency is to heave up large masses of rock rather than to shatter them into smaller fragments.

[1] The author is indebted to publications of the E. I. DuPont de Nemours Co. for many facts regarding explosives.

Dynamite which is rather soft resembles brown sugar. It is packed in paraffine-coated paper shells or cartridges, the standard size being $1\frac{1}{4}$ by 8 inches and containing one-half pound. Other sizes, from $\frac{7}{8}$-inch to 2 inches in diameter and 6 inches and over in length are also manufactured. Dynamite cartridges are packed in sawdust in wooden boxes containing 25 or 50 pounds each.

Dynamite freezes between 35 and 50 degrees Fahrenheit and when frozen must be thawed before use. Thawing kettles which are best for this work consist of a double galvanized iron bucket having an inner water-tight receptacle for dynamite and an outer receptacle for warm water which must not exceed 100 degrees Fahrenheit, otherwise the nitro-glycerine may separate from the absorbent. Cartridges are sometimes spread out on a shelf in a warm room and left during the night but should never be thawed in an oven, near a fire or placed against a stove or steam pipe. A few cartridges can be easily thawed out by placing them flat in a water-tight box and burying them in fresh manure.

Great care must be taken to prevent the dynamite from coming into contact with moisture, because water has a greater affinity for the absorbent than has nitro-glycerine, and the latter will be driven out; on low grades of dynamite the salts of the auxiliary explosives are also expelled.

Dynamite with a high percentage of nitro-glycerine deteriorates during warm weather, when stored in a warm place, or if kept for long periods. Chemical decomposition takes place, liberating nitrous fumes which often are the cause of violent explosions. A greenish color on the cartridges is a certain indication of chemical decomposition, and handling dynamite in such condition is always dangerous.

Nitro-glycerine from the cartridge may be absorbed through the hands, and men who handle dynamite are subject to severe headaches. This may be obviated partially by wearing gloves which should be thrown away as soon as they become saturated.

Loading Holes. — The charge should completely fill the bore hole because explosives exert the greatest disruptive force when there are no air spaces below the tamping.

In loading dry holes the cartridge case is cut on one side, and the cartridge lowered into the hole and gently pressed until it completely fills the bore. This is repeated until a sufficient amount of explosive has been placed. When the hole is wet the cartridge case should not be cut.

The hole is now ready for the primer and for tamping.

Primers and Priming. — Most forms of dynamite are exploded by the use of a fulminate detonator or cap, which is ignited either by a safety fuse or an electric fuse. The former is used for individual charges and the latter where many are to be fired simultaneously.

Safety Fuse and Caps. — There are several grades of safety fuse offered on the market, some of which are waterproofed for submarine work. The fuse used for blasting ordinarily burns at the rate of 2 or 3 feet per minute, and is marketed in packages containing two coils, each 50 feet long.

The cap consists of a hollow copper cylinder $\frac{1}{4}$ by $1\frac{1}{2}$ inches in size which is closed at one end. It is partly filled with from three to twelve grains of fulminate of mercury. The open end is sealed with shellac, collodion, thin copper foil, or paper. Caps deteriorate very rapidly when exposed to moisture. Several grades are made, but for general use a No. 6 is preferred.

In making the primer for an ordinary blast a piece of safety fuse of the required length is cut off and one end inserted into the cap until it comes in contact with the filling. The fuse is held in place by crimping the cap $\frac{1}{8}$-inch from the open end. The fuse and cap are then ready for insertion in the primer, which consists of a cartridge of dynamite of the same size and quality as that used in the charge.

There are two methods of inserting the cap into the primer. A common method (Fig. 76, *a*) is to open the paper at the end of a cartridge, and, with a sharpened stick about the size of a lead pencil, make a hole $\frac{3}{4}$-inch deep in the dynamite. The cap, with fuse attached, is then inserted in this cavity and should project $\frac{1}{8}$-inch above the dynamite, otherwise the sputtering of the fuse may ignite the dynamite before it does the cap. The cartridge paper is then tied around the fuse with a string, care

being taken not to pull the cap out of the primer. If the cartridges are used in wet places soap or tallow is smeared over the safety fuse at the point where it enters the cartridge to prevent the entrance of moisture into the blasting cap.

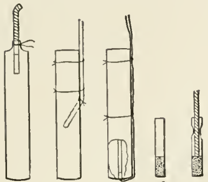


Fig. 76. — Method of placing Caps in the Primer. *a*, and *b*, are for firing with safety fuse. *c*, for firing with an electric battery. *d*, shows the cap ready for the insertion of the fuse. *e*, cap with fuse inserted and the cap shell crimped.

Some persons prefer to use the method of attaching caps shown in Fig. 76, *b*. A hole is punched in the side of the cartridge with a sharp wooden stick and the fuse attached as shown. This method is satisfactory because the fuse comes against the side of the bore and is not injured or disturbed by the tamping bar, and the cap cannot be pulled from the primer and thus cause a misfire.

Primers are placed on top of the charge, but in deep holes, manufacturers recommend that additional blasting caps without fuse be placed at 5-foot intervals throughout the charge.

Electric Fuse. — When it is desired to fire several different charges at one time electric fuses are used in connection with a battery. They consist of two wires inserted in a cap containing a mixture of fulminate of mercury and potassium nitrate or chlorate. The open end of the cap is plugged with sulphur. The fuses are adjusted as shown in Fig. 76, *c*. When an electric fuse is used the primer is often placed in the center of the charge. The practice in electric firing is to separate the two wires on the fuse and connect one to a wire on a charge on one side and the other to one on a charge on the opposite side. The entire set is connected up in this manner leaving one free wire extending both from the first and the last hole. The two leading wires, 250 feet or more in length, are then connected to the above wires and carried to some protected point. When all is in readiness the leading wires are attached to the poles of the battery and the charge fired by an electric firing machine.

Tamping. — Tamping should always be done with a wooden bar, never with a tool having any metal parts, and the tamping

material must be free from all forms of grit, and of such a nature that it will pack firmly. The most satisfactory is moist clay or loam.

After the charge has been pressed tightly in the bore a paper wad may be placed over the primer to keep it dry and from 2 to 3 inches of tamping material put in and firmly, but gently, packed. Two to 3 inches more of tamping material are again added and thoroughly tamped. After 5 or 6 inches of earth have been placed in the bore the tamping can be carried on without fear of premature explosion. The hole should be filled to the surface and the material tightly packed, or it will blow out and much of the force of the explosive will be lost.

Low Explosives. — Low explosives belong to either the soda or the saltpeter class and are known as black powder. The average contain approximately 75 per cent of nitrate of soda, or India saltpeter, 10 per cent of sulphur, and 15 per cent of carbon. Dynamite of 75 per cent strength is usually rated as six times stronger than average black powder. Soda powders can be made cheaper than saltpeter powders but are more absorbent of moisture and, therefore, deteriorate quicker.

Black powders are especially suited for loosening hardpan, shale, and other soft or rotten rock where a lifting action is desired. It is much slower than high-grade dynamite and does not shatter the rock as much. It is also used in redwood operations to blast open logs that are too large to be handled otherwise.

Black powder is fired by a safety fuse, by a safety fuse and a cap of low power, or by an electric fuse. In loading holes the powder may be placed loose or in cartridges. When the holes open downward the latter form is the only method possible.

In priming holes it is customary to place the safety fuse or safety fuse and cap at the top of the charge while electric fuses are ordinarily placed in the center of the charge.

Moist clay is the most satisfactory tamping material, 2 or 3 inches of dry earth being placed over the powder to prevent the upper end of the charge from becoming moist.

When blasting with black powder the holes may be "sprung" with dynamite before the powder is inserted, in order that a

larger cavity may be made for the powder. Dynamite of 40 per cent strength is used for "springing," about $\frac{1}{20}$ of a pound per cubic yard being fired in shale, and $\frac{1}{10}$ of a pound per cubic yard in sandstone. "Sprung" holes should not be charged until they have become cool.

The amount of black powder required per cubic yard of material to be blasted is governed by the depth of hole, character of rock, and spacing of holes. Authorities on the use of black powder do not attempt to give any rules for determining the amount of charge. Charges of 1 pound per cubic yard have proved successful in side cuts and from $1\frac{1}{2}$ to 3 pounds per cubic yard in through cuts.[1] The amount to use under given conditions can be determined only after a few trial shots.

Black powder is put up in 25- or 50-pound cans and costs from 6 to 9 cents per pound.

STUMP BLASTING

The removal of stumps from the right-of-way of roads, trails, logging grades, and from pond and building sites can often be accomplished to best advantage by the use of explosives. Dynamite of the 40 and 60 per cent grades is preferable to black powder for this purpose.

The position of the blast with reference to the stump should be governed by the size of stump, character of root system, and kind of soil. Charges should always be placed immediately under the stump but not in it, and as near as possible to its toughest part.

In sandy soil stumps with a shallow root system require more explosive than those with tap roots.

They blast easier in heavy and moist soils than in light or dry ones.

For blasting yellow pine stumps with long tap roots the charge should be placed near the tap root and at a distance under ground at least equal to the diameter of the stump. Forty per cent dynamite is usually preferred.

[1] See "Handbook of Cost Data," by H. B. Gillette. Myron C. Clark Publishing Company, Chicago, Ill., 1910. P. 204.

Cypress stumps have many lateral roots and since they usually grow on mucky soil they are difficult to blow out. A quick powerful explosive, such as 60 per cent dynamite, is recommended by manufacturers. The common practice with swamp species is to place a $\frac{1}{2}$-pound cartridge under each large lateral root, and 4 or 5 pounds under the center of the stump. The charge is then fired with an electric blasting machine.

Stumps with defective centers often split apart and allow the force of the explosive to pass upward without blowing out the roots. This can be obviated by placing a chain around the top of the stump.

Where a right-of-way must be cleared of stumps, it is easier to blow them out before the tree is cut because the weight of the crown helps to pull out the roots.

The holes in which the explosive is placed are best bored by a 2-inch auger welded to a 5-foot iron rod that has a ring on the upper end through which a round stick can be inserted for a handle.

The depth of the charge below the stump should be governed largely by the size of the stump itself. Dynamite, in exploding, tends to exert a force equally in all directions. When placed under a stump the soil below the charge offers greater resistance than the soil above and the force is exerted upward in the form of an inverted cone. Consequently the deeper the charge is placed the wider the cone at the surface of the earth.

A rule[1] followed with success in Minnesota was to place the charge at least 1-foot deep for all stumps 1 foot or less in diameter, and proportionally deeper as the diameter increased.

Holes are charged, primed and tamped in a manner similar to bore holes in rock. Enough explosive should be placed under the stump to remove it at the first shot, because it is difficult to make an effective blast in loosened dirt.

One thousand stumps, ranging from 18 to 48 inches in diameter and averaging 30 inches, which were blasted in Minnesota required from one-half to eight, 40 per cent dynamite cartridges, the average number being three per stump.

[1] See Minnesota Farmer's Institute Annual, No. 21, 1908.

The DuPont Powder Company recommends, in general, a charge of $1\frac{1}{2}$ pounds of 20 per cent dynamite for each foot in diameter of stump, up to 4 feet; above this diameter $2\frac{1}{2}$ pounds per foot in diameter.

On dry ground one man can bore holes, load, and blow out an average of fifty stumps per day, if they are not widely scattered.

TIMBER WORK

The construction of trestles, culverts, cribbing, and other timber work is done just previous to track laying.

Trestles. — These are used in crossing streams and depressions where the cost of a fill would be excessive. They are cheaper to build than heavy fills and when the road is used for a short time only, the trestle timber can be taken up and used on another line.

They are built in two types known as pile trestles and frame trestles, and are made in sections, called bents, which are spaced 12 or 14 feet apart.

Pile trestles are used largely in stream beds and swampy spots where good foundations for framed trestles cannot be secured. Low pile trestle bents usually consist of three round piles from 12 to 15 inches in diameter, driven in a row across the roadbed. On a standard gauge road one pile is placed in the center of the roadbed and the outer piles are placed from 24 to 28 inches on either side of it. On medium height trestles for standard-gauge track four piles are used, the two inner ones being spaced 3 feet apart, center to center, and the outer piles 26 inches, center to center, on either side of the middle ones.

They are driven with a pile driver to bed rock, or solid bottom, and are sawed off at the required height above ground. A 10 by 10-inch, a 12 by 12-inch, or a 15 by 15-inch timber, called a "cap," is drift bolted on top of them with $\frac{3}{4}$ by 21-inch drift bolts.

The bents are connected by stringers, each 8 by 14 inches or 9 by 16 inches in size, which are placed at right angles on top of

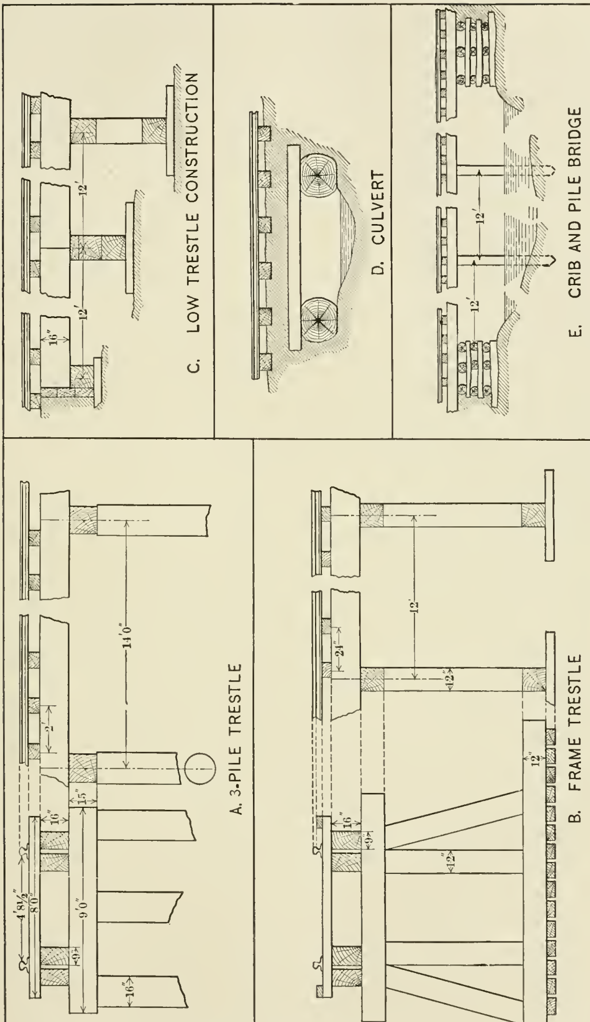


FIG. 77.—Forms of Trestles and Culverts commonly used on Logging Railroads.

the caps and support the crossties. Two stringers are used under each rail. They are spaced 2 inches apart with washers, and then bolted together. They may also be drift-bolted to the caps to hold them in position. Sawed ties, 6 by 8 inches by 8 feet, are placed 24 inches, center to center, on top of the stringers, and are often sunk about ½ inch into them. An occasional crosstie is also drift-bolted to the stringers. Three- by 8-inch guard rails are then placed on top of the ends of the ties parallel to the stringers and spiked to every other tie to prevent the ties from bunching.

Where the trestle is less than 9 feet high it is seldom braced, but where the height exceeds this it is braced on each side with 3- by 6-inch scantlings placed diagonally across each row of piles, the top end of the brace being fastened to the cap and the lower end to the opposite side of the bent just above the ground. The scantlings are spiked to the cap and to each pile.

Where the bent exceeds 20 feet in height it is divided into two stories by horizontal braces of 3- by 8-inch scantling, and each story is braced diagonally in the manner described above. At each story every bent is connected by a longitudinal brace. Bents over 20 feet in height consist of five piles whose diameters should not be less than one-twentieth of their length. One pile is placed in the center of each bent and two others are placed on either side at a distance of approximately 24 inches, center to center. The two other piles are placed about one foot out at the top of the bent and are given a batter of 2 inches for each foot of height.

In swampy sections the main line is sometimes built on piling. The advantage of this form of road is that a firm foundation is secured in places where dirt ballast could not be used, stumps need not be removed, and the cost of maintenance for the first few years is low.

In cypress swamps these roads are made of piles from 12 to 15 inches in diameter, driven down to a solid foundation, which may be from 60 to 80 feet. Piles 30 feet long are made from one cypress stick but lengths greater than this are secured by placing one pile on top of another. Cypress is used for

the top log and tupelo for the lower ones. The bents are placed at 6-foot intervals and are composed of two piles driven $56\frac{1}{2}$ inches apart, center to center.

A pile driver crew for building a road of this character is made up of eight men who can cut and drive from twenty to thirty-six piles (from 60 to 100 feet of track) per day of ten hours. The roads are built from 2 to 6 feet above the ground level, and the piles are sawed off at the desired height.

Stringers 8 by 8 inches, or 8 by 10 inches, are laid on top of the piles and on these 6- by 8-inch by 8-foot crossties are laid, 24 inches center to center.

Thirty-five or 45-pound steel rails are used.

Rod locomotives of from thirty to forty tons are generally employed.

The approximate cost, per mile, of a road of this character is $1400 for labor, and $1100 for stringers and crossties.

A road of similar character constructed on swampy ground in the State of Washington cost $1300 per mile, exclusive of the value of the timber used.[1]

Framed Trestles. — These are made both of round and squared timbers, but if the former must be brought from a considerable distance it is advisable to use the latter because they are easier to fit, and are more durable.

The frames, or bents, consist of four supports, or legs, made of round timber from 15 to 18 inches in diameter or 10- by 12-inch, or 12- by 12-inch squared timbers. On a standard-gauge road two of the legs are vertical and 36 inches apart, while the other two legs are given a batter of from 2 to 3 inches for each foot of height. The legs rest on a timber called a sill to which they are drift-bolted. Sills vary in length according to the height of the trestle and project about 2 feet beyond the base of the outer legs. The tops of the legs are covered with a cap 12 or 14 feet long on which the stringers rest.

Framed bents may rest on mud sills, or piles. Where mud sills are used they are frequently 12 by 12 inches by 4 feet and are placed at right angles to the bent, and a sufficient number

[1] See The Timberman, August, 1910, pp. 37–38.

are used to provide a greater bearing surface than that offered by the main sill.

Mud sills are suited for a bottom solid enough to provide a firm support but they are not adapted for use in swamps or stream beds. The foundations used in the two latter cases consist of piles driven to bed rock, one being placed under the base of each leg, and cut off 2 or 3 feet above high-water mark.

Photograph by R. C. Hall.

FIG. 78. — A Round Timber Framed Trestle on a Logging Railroad. The large skidway on the right is several feet below the level of the track. Alabama.

Stringers, ties and guard rails are used as on a pile trestle, and the bents are braced in the same manner.

Cost of Trestles. — Framed trestles are frequently built by contract, the price being regulated by the amount of timber used and the height of the trestle. The labor charge for trestle construction where the structure is less than 10 feet in height is from \$2 to \$4 per thousand feet of timber used, while high trestles may cost from \$7 to \$10.

Payment for pile trestles, when built by contract, is made on the basis of the number of piles driven and the amount of sawed timber used in the remainder of the structure.

Dunnage or Dust Road. — This is a type of cheap logging road employed for spurs in the cypress swamps of Louisiana where the bottom is too soft for dirt ballast, and the cost of a pile road is not warranted by the amount of timber to be removed.

FIG. 79. — The Foundation for a Dunnage Road. Louisiana.

The construction of a dunnage road is preceded by clearing a right-of-way from 15 to 20 feet wide from which all brush is cut and stumps removed from the line of the roadbed. The latter is covered with small poles from 5 to 6 inches in diameter, laid close together, lengthwise of the right-of-way. These give a wide bearing surface and serve as a bed on which the ballast is placed. The crossties are laid on the poles and the rails spiked

to them. The track is then ballasted with bark, edgings, sawdust and sawmill refuse of all sorts which is brought from the mill in "dunnage" cars. The dunnage is dumped on either side of the rails, then thoroughly tamped under the ties and, when the track is leveled up, it is ready for operation. Light-weight locomotives, from 18 to 30 tons, are used because this type of roadbed will not stand heavy traffic.

The labor cost of constructing dunnage roads including the laying and taking up of steel is from $1300 to $1500 per mile.

Cribwork. — A crib foundation may be used when logging railroads cross low places that are too soft for a fill, and where the lumber company is not prepared to put in piling. Logs 18 or 24 inches in diameter and 16 or 18 feet long are placed across the right-of-way at intervals of 8 feet. On top of these, and parallel to the roadbed, round stringers from 18 to 24 inches in diameter are placed $56\frac{1}{2}$ inches, center to center. These are notched into the cross-skids and drift-bolted to them. The crossties are then laid on top of these stringers. The cross-skids are given a greater bearing surface by placing "shims" or poles from 4 to 6 inches in diameter and 8 or 10 feet long at right angles under them.

Labor on work of this character costs from $4 to $6 per thousand feet of timber used.

Corduroy for Logging Roads. — An excellent practice followed by some loggers in the South is to corduroy unballasted spur tracks on wet ground with 16- or 20-foot poles from 4 to 12 inches in diameter (Fig. 80). A pole is placed in the space between the ties and projects out far enough on either side to rest on solid ground or roots. The poles provide a level support to the track. Even though it does sink temporarily under the weight of the train, it will go down on a level, so that there is no danger of derailment, while shims placed under the ties parallel with the roadbed often allow the track to settle on one side.

When spurs cross swampy ground, some loggers dispense with ties, and cover the roadbed with poles 10 or 12 feet long to which the rails are spiked. A road of this character will support light traffic even on a very wet bottom.

Culverts. — These are used where the grade crosses very small streams, or slight depressions where it is necessary to have drainage from one side of the grade to the other.

They are ordinarily made by placing logs from 18 to 30 inches in diameter across the right-of-way on either side of the stream

FIG. 80. — A Spur Logging Railroad corduroyed with Poles. Arkansas.

and covering them with slabs split from 12- to 18-inch timbers. Brush is often piled on top of the slabs to prevent the dirt from falling through, and the grade is then built over the culvert. Box culverts made of plank are seldom used because of the greater cost for material. Round galvanized iron culverts are now used on some main lines.

Cattle Guards. — Log roads that pass over private lands or cross public highways use cattle guards to prevent stock from passing down the right-of-way. The usual type is an open pit 3 or 4 feet deep, $5\frac{1}{2}$ feet long and 3 or 4 feet wide, which is inclosed with a frame of 12- by 12-inch timbers. A division fence extends from the guard to the highway fence.

This form of cattle guard is dangerous if cars are derailed on them, because the trucks will drop into the pit. Animals also may fall in and cause a wreck. They are, however, a convenient and cheap form to construct and are in favor on that account.

TRACK SUPPLIES

Crossties. — The size of crossties used depends on the gauge of the road. They may be sawed or hewed. Narrow-gauge ties are made 6 or 7 feet long and standard-gauge ones are 8 feet. Squared ties are frequently 6 by 8 inches in size and pole ties for a narrow gauge have a 3- to 5-inch face, and for a standard-gauge a 6-inch face.

Ties are usually cut on the operation and are made both from hardwoods and softwoods. The work is generally performed by contract, the rate being from 10 cents to 15 cents each for making standard ties and from 8 to 10 cents for narrow-gauge pole ties. Hauling to the railroad costs from 2 to 4 cents per tie and loading on cars from 1 to 2 cents.

An expert tie hacker will hew thirty-five or forty standard ties per day, an average man twenty-five or thirty.

They are placed at 2-foot intervals, center to center, on main lines and spurs. On the latter they wear out before they decay, because of the frequent pulling and driving of spikes.

Crossties of special length are required for a switch. The timbers in a set for a single switch range in length from 9 to 15 feet and the number varies with the frog; *e.g.*, a number 8 frog requires 47 and a number 10 frog 56. These are often sawed out in the mill. On rough track the long switch ties may be replaced by two standard length ties.

Steel Rails. — Rails are classified according to their weight in pounds per lineal yard, and those of a given weight are now made of a uniform size.

The chief parts of a rail are the head, the web, and the flange base. The head contains 42 per cent of the metal, the web 21 per cent and the flange 37 per cent.

WEIGHTS AND DIMENSIONS OF STANDARD RAILS[1]

Rail part.	Weight per yard in pounds.							
	40	45	50	55	60	65	70	75
	Dimensions in inches.							
A	$1\frac{7}{8}$	2	$2\frac{1}{8}$	$2\frac{1}{4}$	$2\frac{3}{8}$	$2\frac{13}{32}$	$2\frac{7}{16}$	$2\frac{15}{32}$
B	$\frac{25}{64}$	$\frac{27}{64}$	$\frac{7}{16}$	$\frac{15}{32}$	$\frac{31}{64}$	$\frac{1}{2}$	$\frac{33}{64}$	$\frac{17}{32}$
C and *D*	$3\frac{1}{2}$	$3\frac{11}{16}$	$3\frac{7}{8}$	$4\frac{1}{16}$	$4\frac{1}{4}$	$4\frac{7}{16}$	$4\frac{5}{8}$	$4\frac{13}{16}$
E	$\frac{5}{8}$	$\frac{21}{32}$	$\frac{11}{16}$	$\frac{23}{32}$	$\frac{49}{64}$	$\frac{25}{32}$	$\frac{13}{16}$	$\frac{27}{32}$
F	$1\frac{55}{64}$	$1\frac{31}{32}$	$2\frac{1}{16}$	$2\frac{11}{64}$	$2\frac{17}{64}$	$2\frac{3}{8}$	$2\frac{15}{32}$	$2\frac{35}{64}$
G	$1\frac{1}{64}$	$1\frac{1}{16}$	$1\frac{1}{8}$	$1\frac{11}{64}$	$1\frac{7}{32}$	$1\frac{9}{32}$	$1\frac{11}{32}$	$1\frac{27}{64}$

[1] From the International Library of Technology, Vol. 35B, §57, p. 9.

Rails are sold by the long ton. Although the standard rail length is 30 feet, shippers reserve the right to include 10 per cent of from 24- to 28-foot rails in a given order.

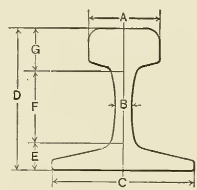


Fig. 81.—A Standard Rail Head. A, the head. B, the web. C, the flange base.

Narrow-gauge roads use 25- or 35-pound rails; and standard-gauge 35- or 45-pound rails on spurs, and from 45- to 70-pound rails on main lines. The lighter rails are an advantage on spurs because they can be handled more readily.

The long tons of rails of different weights required per mile of road may be found by multiplying the weight per yard by 11 and dividing the result by 7.[1] Ordinarily the weight of the rail in pounds per yard should equal the number of short tons carried on all the drivers of the heaviest locomotive that is to be used.

[1] Example: weight of rail, 60 pounds per yard; then $\frac{60 \times 11}{7}$ = 94 tons, 640 pounds.

For example, a locomotive having a weight of 80,000 pounds on its drivers should not be operated on less than a 40-pound rail.

Lumber companies frequently buy or lease second-hand rails from trunk-line railroads. The latter practice is common in some sections, where trunk lines have second-hand steel, which accumulated when a change in the weight of the rails was made on their lines. The lease of steel at low rates serves to encourage the development of the lumber industry along the trunk line because it reduces the lumberman's investment in equipment.

The price of new rails at steel mills is about $32 per ton.

Rail Fastenings. — Either angle bars or fish plates are used to strengthen and brace the rails at the joint.

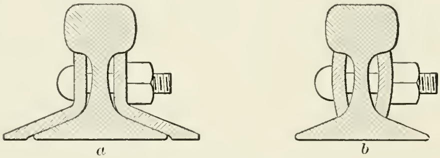


Fig. 82. — Forms of Rail Fastenings. *a*, angle bars. *b*, fish plates.

Angle bars, which are of several patterns, are bolted on each side of the joint with from two to three bolts in each rail head (Fig. 82, *a*). They are used on main-line logging roads.

Fish plates, sometimes called "straps," are plain bars of steel bolted to the rail in the same manner as the angle bars, but usually with not more than two bolts per rail head (Fig. 82, *b*). They are especially adapted for logging-spur tracks, because they can be put on quicker than angle bars and are equally serviceable for light traffic.

Standard requirements call for 357 joints per mile.

Spikes. — Rails are fastened to the crossties by square spikes which vary in length and size with the weight of rail. Four spikes are driven to each tie, one on each side of each rail.

ESTIMATED AMOUNT OF MATERIAL REQUIRED FOR ONE MILE OF TRACK FOR RAILS OF A GIVEN WEIGHT

Weight of rails per yard........	16	20	25	30	35	40	45	50	55	60
Number of tons of 2240 pounds.	25.14	31.42	39.28	47.14	55.00	62.85	70.71	78.57	86.42	94.28
Pounds of spikes..	2090	3110	3520	3520	3520	5170	5170	5170	5170	5870
Number of angle bars	357	357	357	357	357	357	357	357	357	357
Number of cross-ties............	2640	2640	2640	2640	2640	2640	2640	2640	2640	2640
Pounds of bolts and nuts	318	335	353	764	1124	1124	1124	1171	1217	1825

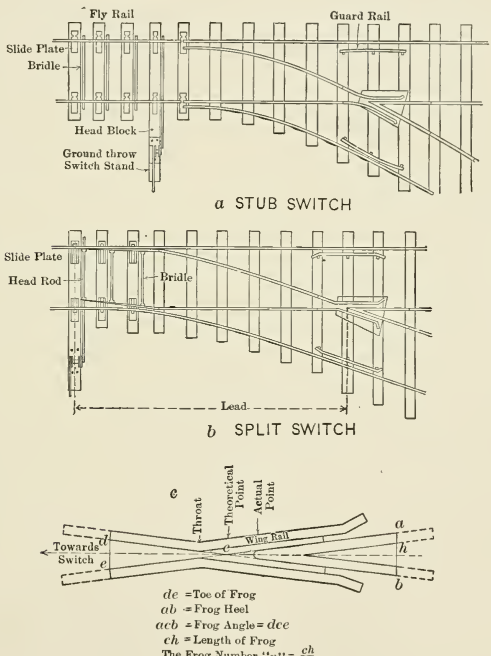


FIG. 83.—Two Forms of Turnouts used on Logging Railroads. *a*, the stub switch. *b*, the split switch. *c*, a standard frog.

Turnouts. — The device used to connect two given sets of track is known as a turnout. It consists of three separate parts known as the switch, the frog and the guard rails.

(1) The switch is the moveable part of the turnout and is the point at which the two divergent tracks meet. There are two kinds in use by loggers; (*a*) the stub-switch in which both mainline rails are cut (Fig. 83), and (*b*) the split switch in which but one main-line rail is cut (Fig. 83). The latter is preferred because of its greater safety.

(2) Frogs provide the means by which the flanges of the wheels can cross the rail of the track when the train is entering or leaving a switch (Fig. 83, *a*). Frogs are built ready for use in the track and are made for various degrees of curvature, each size being designated by a number. Those in most common use on standard-gauge logging roads are No. 6 ($9° 32'$), No. 8 ($7° 09'$) and No. 10 ($5° 43'$). The number of a given frog can be determined by dividing the length of frog by the width of the frog heel, the quotient being the frog number.

(3) Both on the main line and the spur, guard rails, from 10 to 15 feet long, are placed opposite the frog and serve to hold the wheel flanges against the outer rail and thus make the wheel flanges on the opposite side of the car follow the proper rail. The space between the head of the guard rail and that of the main rail is 2 inches.

STEEL LAYING AND REMOVAL

Steel laying and removal may be performed either by hand labor, or by track-laying machines. The work is done both by contract and by day labor, although the latter is the more common.

A crew of from twenty-one to twenty-five men, provided with a light engine, and one or more cars carrying crossties, rails and other supplies, will lay by hand from 1500 to 2000 feet of track, daily, at a cost of from $1\frac{3}{4}$ to 2 cents per linear foot. Rails and ties are carried on flat cars each holding from fifteen to twenty pairs of rails with the required number of ties. The cars are pushed ahead of the locomotive to the point where construction

is to begin. Ties are then laid in position on the right-of-way, and the rails placed on them. The rails are connected by angle bars or fish plates and spiked to every third or fourth tie. This gives the rail sufficient bracing to hold up the train which is pushed forward a rail length and the operation repeated. In taking up track this process is reversed. The cost is about the same as for laying track.

Spurs are moved with such frequency that it is seldom feasible to carry a stock of bent rails for curved portions of the track. In nearly all cases it is practicable to bend the rails to the proper curve as they are spiked. On main-line work a rail-bending machine is sometimes employed.

Where spurs are being built constantly the steel-laying crew may spend alternate days in removing steel and ties from an abandoned road and in placing them on a new roadbed.

On main lines the expansion of the rails during warm weather must be taken into account in order to prevent buckling. To remedy this a space of $\frac{5}{16}$ of an inch in winter and $\frac{1}{16}$ of an inch in summer is left between rail ends. On spurs the rails seldom fit closely so that this factor may be disregarded.

During recent years several mechanical devices have been invented to simplify and cheapen track laying and removal. The machines now offered are of two general types: (1) those that handle the rails and ties in sections or panels one rail length long; (2) those that handle rails and ties separately. The first method is best adapted for flat lands where there are few curves and turnouts on the line, for where these occur the track sections must be broken up before they can be relaid. The rails are laid with "even joints."

An operation in Florida using a double-track locomotive crane employs a train made up of a locomotive, four flat cars and the track mover at the rear end. The train is backed out to the end of the line that is to be taken up, the bolts on one end of the fish plates are removed, and four chains are attached near the center of a 30-foot section, which is elevated several feet by a cable on the track mover. The latter is then revolved in an arc of 180 degrees and the section deposited on the flat car directly behind

it. The train is then run forward a rail length and the process repeated. When ten sections, or 300 feet of track, have been placed on a flat car, it is switched out by the locomotive and an empty substituted. After loading four flats with 1200 feet of track, the train proceeds to a new line where with the track mover ahead the process is reversed and the track laid.

The track-laying crew on this operation consists of one track foreman, who runs the track-moving machine, one negro laborer on the flat car to fasten and loosen chains, and three or four negro laborers on the ground to handle the section, bolt up and unbolt fish plates and perform similar work.

The cost of laying and taking up track is approximately 2 cents per foot. This crew, in addition to averaging 2000 feet of track daily, clears the right-of-way and cuts wood for fuel.

To obviate the difficulty of handling turnouts and curved sections a machine has recently been patented for handling rails and ties separately. The machine is mounted on a flat car and has a system of endless transfer chains which run from one end of the car to the other and project over the forward end to the outer edge of a cantilever, the end of which may be lowered or raised as necessary. The transfer chains may be operated in either direction and are used for the transport of ties from the track to the storage space on the car, or vice versa.

A trolley system for handling the rails extends along both sides of the machine and projects beyond the forward end for a distance sufficient to permit the loose rails to be gripped at the center by a block and tackle suspended from the trolley.

Power for driving the various working parts of the machine is supplied by an engine which is provided with steam by the locomotive. It is mounted on the rear of the car.

In taking up track the machine is run out to the end of the line. After the track is broken up the rails are gripped near the center, hoisted off the ground, carried to the rear on a trolley and stored along the sides of the machine. The ties are placed on the transfer chains by laborers, and transported to the car. When one panel has been taken up the car is moved back for

another panel length and the operation repeated. For track laying the process is reversed.

A device for handling rails and ties at an operation in Oregon[1] consists of an 8- by 10-inch, or 9- by 10-inch donkey engine equipped with two drums having 24-inch barrels and a capacity of from 1200 to 1400 feet of $\frac{3}{4}$-inch cable, and an "A" boom on which are hung two blocks, one in the peak and one midway between the peak and the frame on which the equipment is mounted.

The donkey is placed on a car and, with an empty flat in front, is run out on the track to be taken up. The machine can operate only on straight stretches of track; hence, where there are frequent curves, a set-up must be made at the head of each curve. The maximum range of the machine is from 1000 to 1200 feet.

A cable is run from the peak block to another block which is attached to a tree or stump about 30 feet to one side of the track. A second cable is also run from the lower block to one on the opposite side of the track. The lines are then dragged by a horse to the end of the spur.

The bolts are removed from one end of the fish plates, and the latter left on the rear end of each rail. The cable is then attached to the rail and it is drawn forward beside the next one. When four rails are attached they are drawn in along the side of the empty car, and loaded with the line from the peak block. About sixty-four ties are made into a pile, a choker placed around them, and the pile drawn in at the side of the flat car where they are loaded by hand. In ten hours, twelve or fourteen men can pick up and load from 1200 to 1400 feet of track without the assistance of a locomotive.

Track-laying crews are followed by back spikers, who complete the spiking of the track. On main line and curves four spikes are placed in each tie, two for each rail, but on spurs every other tie may be spiked. The track can be taken up more readily if it has a minimum number of spikes to pull and the life of the tie is also increased. A crew of seven men will back-spike 1600 feet of track per day.

[1] The Timberman, Portland, Oregon, August, 1912, p. 48.

The back-spiking crew is followed by the surfacing gang who level up the roadbed with ballast, dig or open drainage ditches alongside of the track, adjust the gauge, raise the outer rails on curves, and perform any work necessary to put the road in a condition for operation. On main lines a large amount of surfacing may be done, but on spurs it is limited.

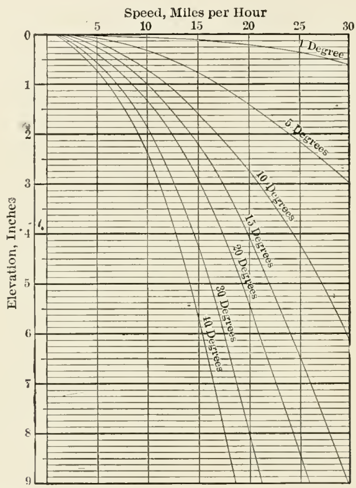


FIG. 84. — Diagram showing the Customary Elevation of the Outer Rail, in Inches, for Various Degrees of Curvature.

Roads which have sharp curves must have the gauge widened to reduce the frictional resistance of the wheels against the rails. It is customary to widen the gauge at least $\frac{1}{16}$-inch for each $2\frac{1}{2}$ degrees of curvature in excess of 5 degrees. For example, the gauge would be increased $\frac{1}{2}$-inch for a 20-degree curve. The extra width allowed is dependent chiefly on the width of the car wheel treads.

The centrifugal force of a train under speed tends to force the wheels against the outer rail. This tendency increases with

speed and is greater on a sharp curve than on an easy one. It is overcome by elevating the outer rail and lowering the inner one and also by coning the tread of the wheels. The diagram (Fig. 84) shows the customary elevation for standard-gauge track on curves up to 40 degrees and for speed up to 30 miles per hour.

The elevation for track of another gauge is approximately in proportion to its relation to the standard-gauge.

On light work forty men may surface and put in condition about one mile of road per day, at a cost of from \$60 to \$75 per mile, while on main lines the cost may be \$600 or more per mile.

Cost of Construction. — The cost of construction per mile on logging railroads varies widely even in a given region. The two factors that greatly influence it are topography and the character of the bottom on which the road is to be built.

Construction is cheapest in the flat pine forests of the extreme southern States, where a minimum of grading is required. On the other hand the rough topography of some of the Pacific Coast country often requires heavy grading work and high trestles and the roads must be built more carefully for transporting the large and heavy timber. Swamps such as are found in the cypress region also necessitate a heavy expenditure because the main roads have to be built on piling.

Loggers in all sections spend a maximum of from 50 to 75 cents per thousand feet of timber hauled for the construction of the road, from 20 to 30 per cent of which is expended on the main line. The cost of main line logging roads, exclusive of rails and other supplies, in the southern pine region ranges from \$700 to \$2000 per mile, and on the Pacific Coast between \$3000 and \$6000. Spur lines in the South cost from \$250 to \$600 and on the Pacific Coast from \$1500 to \$2000 per mile. The cost of a main line including new steel rails, angle bars, spikes, crossties and supplies will exceed the figures given by from \$3000 to \$3500 per mile.

Maintenance-of-Way. — Section crews are employed to keep the road ballasted up, maintain the gauge, keep the drainage

ditches open, replace broken or decayed ties and to make any repairs that may be required. A crew of five men under a section foreman will keep in order six miles of main line or from eight to twelve miles of spur road.

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CHAPTER XIX

INCLINES

Loggers in mountainous regions often find it necessary to raise or lower loaded log cars on grades too steep for the operation of locomotives. These conditions may be encountered in bringing timber over a ridge from one valley to another, or from a ridge to a lower level on which the logging railroad is located, or vice versa. Logging inclines are often used to overcome difficulties of this character.

A common type is one in which a heavy hoisting engine and a large drum are placed at the head of the grade and the cars are drawn up, over a wooden or a steel rail track, by a cable with one end attached to the front car and the other wound on the drum.

The roadbed does not demand the heavy construction required where trains pass, because there is no pounding action such as is produced by a locomotive. An uneven grade is not a serious handicap unless there are portions which are so gentle that cars cannot be returned to the foot of the incline by gravity, in which case a trip line must be provided which will pass from the hoisting engine through a block at the foot of the incline and then back to the summit. The main cable[1] is usually 1 inch or $1\frac{1}{4}$ inches in diameter, and the trip line $\frac{5}{8}$-inch.

The wear on a cable from friction is great and to reduce this it is customary to place wooden rollers in the center of the track over which the main cable may run. Overhead rollers supported on a framework are used to hold the cable down where there are sudden rises in gradient.

Inclines should be built approximately in a straight line because greater power is required when the direction of pull is changed and the life of the cable is shortened when it passes

[1] The most satisfactory cable is one with 5 or 6 strands of 7 wires each.

over rollers at curves. The maximum efficient length for an incline seldom exceeds 8000 feet.

When loaded cars are hauled up one slope and dropped down on the other side, the distance on the downgrade should not exceed the maximum for an upgrade haul.

An incline in Montana which transports mining stulls upgrade to a flume 6600 feet distant uses 16-foot steel rails weighing 88 pounds each. The lower 5000 feet of the road has a 7 per cent grade, and the remaining 1600 feet a 12 per cent grade. Power for hauling up the cars is supplied by three boilers having about 80-horse-power capacity which furnish steam for a 50-horse-power engine. The latter drives the drum which holds 6800 feet of 1-inch cable.

The cost of construction was as follows:

834 rails, 36½ tons, at $40 per ton	$1,460.00
Grading and laying track	4,470.00
Spikes, 1750 pounds at 2 cents	35.00
Bolts, 3336 pounds at 3 cents	100.00
Fish plates, 1668 pounds at 5 cents	83.40
Hauling steel to tram at $20 per ton	328.50
Crossties, 4470 at 50 cents each	2,235.00
4 cars at $40 each	160.00
6,800 feet of 1-inch cable, delivered at tram	3,425.00
3 boilers, drum and engine (2nd hand) installed	2,000.00
	$14,296.90

The average daily output is either 800 stulls 8 inches and over in diameter or 1100 5-inch to 7-inch ones. The annual capacity is 150,000 stulls.

The daily labor charge is as follows:

2 men at the flume dump at $3 each	$6.00
3 car loaders at $3 each	9.00
1 engineer at $4	4.00
1 foreman	3.50
Total	$22.50

There are several devices, known as "snubbing machines," used for lowering logs down an inclined track.

The chief feature of the friction-brake snubbing machine is a heavy frame, carrying a large drum on which is wound the cable that holds the loaded cars in check. The speed of the cars

is regulated by means of heavy band brakes placed on flanges attached on either side of the drum.

The haul cable is returned to the top of the incline by various devices. One type consists of a small drum placed on one end of the main drum shaft and has a trip line from a yarding engine wrapped two or three times around it. When the main cable is to be wound up, the trip line is tightened by sheave pulleys, and, as it is wound in, the main drum is rotated.

Another method used is to employ a donkey engine equipped with a large drum and $1\frac{1}{8}$-inch cable with the cars attached to the free end. The speed is controlled largely through the car brakes supplemented by friction brakes on the drum. Empties are brought to the head of the incline by winding in the main cable.

On some inclines the empties are brought up by a gravity plane. The snubbing device consists of a large drum equipped with friction brakes and provided with a cable which is passed three or four times around the drum to prevent slipping. A single track provided with an automatic switch at a point midway between the head and foot of the incline is used.

In operation loaded cars are attached to the cable at the head and empty cars at the base. The loaded cars proceed down by gravity, passing the empties on the midway switch. When a loaded car reaches the base the cable is removed and attached to an empty and another loaded car attached at the upper end and the trip repeated.

Hydraulic machines for controlling the speed of cars lowered on inclines are used to some extent in the Northwest.

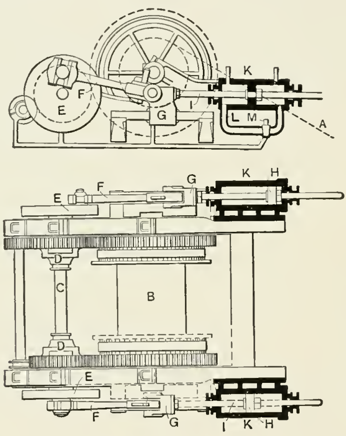
A device[1] of this character is shown in Fig. 85, *a* and *b*.

The water cylinders (*K*) are closed at both ends and are connected with the pipe (*L*) which has a plug valve (*M*) near the middle. When (*M*) is closed the water is confined and holds the pistons (*H*) rigidly in place. Opening the valve (*M*) allows the water to pass alternately from one end of the cylinder to the other, the speed being governed by the extent to which the valve is opened. The controlling levers are so arranged that the valves

[1] See The Timberman, Portland, Oregon, October, 1909, p. 51.

(M) can only be opened and closed gradually, thus avoiding heavy shocks on the cable. In addition to the hydraulic cylinder brakes the machine is equipped with emergency brake bands and wooden friction blocks. The cable and empty cars are returned to the head of the incline by an auxiliary steam-driven engine.

A snubbing device of the above character was operated on a 4500-foot incline on which there was a difference of 1300 feet elevation. The grade on a portion of the road was 50 per cent and averaged 30 per cent for the entire distance.



b

Fig. 85.—A Hydraulic Snubbing Machine *a*, side view. *b*, top view.

One car holding 6000 feet, log scale, a total weight of about 20 tons, was lowered with a 1-inch plow steel cable. A greater number of cars could have been handled by increasing the size of the cable, but since the daily requirements were only 30,000 feet, log scale, this was unnecessary.

In a western operation, which had a 20 per cent grade near the end of its logging railroad, the problem of lowering cars was solved in the following manner: A track was built up the slope from the main line to a bench on which a yarding engine was

placed both for skidding logs and loading cars. A $\frac{5}{8}$-inch cable was laid along the track from the bottom of the incline to the top where it was passed through a block in the rear of the yarding engine and then carried down the track to the starting point. One end of the cable was attached to the forward end of the empty cars, and the other end to the drawhead on a locomotive standing on a parallel track beside the empty cars. The elevation of the cars was accomplished by running the locomotive on the main line toward the mill which hauled the empty cars from the parallel track to the main incline track and then to the summit. Signals for starting and stopping were given by blasts on the whistles of the locomotive and the yarding engine. The speed of descending cars was controlled by the locomotive as it slowly backed toward the base of the hill.

Safety switches were installed at both the top and bottom of the incline so that the cars passing up or down could be shunted off the main track onto a siding before they would meet other cars or the locomotive.

Two loaded cars were handled at one time, the locomotive placing two empties at the head of the incline and then taking the loaded cars to the mill. This arrangement resulted in a minimum loss of time for the train crews.

Dudley. — Where it is not possible to build a straight track, and the length of incline exceeds $1\frac{1}{2}$ miles, a special form of traction device, called a "Dudley" or "Dudler," is used. It is made to operate, loaded, on ascending or descending grades and either to drag logs over the ties or to haul them on cars.

Dudleys are often built in the shop of the lumber company. A type used on a western operation has an 18-inch steel "T" beam frame, 36 feet long mounted on two sets of double trucks, with an 8-foot gauge. The boiler and the link-motion 14 by 14-inch engines are mounted over one of the sets of double trucks, and a water tank is placed over the other set.

The traction device consists of a drum or gypsy wheel 6 feet in diameter with a 12-inch face set midway of the frame and 2 feet inside one of the rails. Underneath the frame at each end an open sheave is placed in line with the gypsy wheel and serves

to receive or discharge a $1\frac{1}{4}$-inch steel driving cable and provides a straight lead on to the main drum.

The cable runs through one of the open sheaves on the end of the frame, passes under and three times around the gypsy wheel, then passes out from under the drum through the other open sheave. The lead sheaves hold the cable just 2 feet inside of the rail. On curves the cable is held in place by wooden pegs placed far enough apart to clear the sheaves. The base of the latter is level with the rail head and when the cable has been picked up and has passed around the drum, the opposite sheave deposits it again in its proper position on the ground. The cable is stretched tight and is fastened to stumps or other rigid supports at the head and base of the incline. The remaining 6 feet between the cable and the other rail is used as a runway for logs and is saddled out midway between the wire and the rail to form a channel.

When a standard-guage track is used there is not sufficient room between the rails for both the cable and the logs. The Dudley is then equipped with two gypsy wheels and two cables, one of which operates just outside of each rail. The cable is prevented from binding on curves by differential gears which permit the drums to travel at different speeds when rounding curves.

On roads of this character care must be taken to avoid sudden changes of gradient, otherwise the cable when at rest will not remain in contact with the cross skids.

When the Dudley is to be used to drag the logs the roadbed is made of cross skids from 24 to 36 inches in diameter and 10 or 12 feet long, placed 6 or 8 feet apart, center to center, and on these 40-pound rails are laid.

As the large gypsy wheel revolves in one direction or the other the Dudley is pulled forward or backward, the cable remaining stationary.

The logs are made up into turns connected by means of grabs. On a road in Oregon, 14,000 feet long, having grades ranging from 5 to 20 per cent a machine of this type hauled from 15 to 20 logs (25,000 to 30,000 feet) per turn. The speed

attained both empty and loaded was approximately 4 miles per hour.

The cost of operation was 30 cents per thousand feet, log scale, for labor and skid oil, and 20 cents per thousand feet for cable, making a total cost of 50 cents exclusive of the value of equipment.

Machines of a somewhat different type but operating on the same general principle are made for hauling log cars. The track is made standard-gauge and the gypsy wheel is placed in the center of the frame, and the cable midway between the rails.

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CHAPTER XX

MOTIVE POWER AND ROLLING STOCK

A. LOCOMOTIVES

There are two general types of locomotives; namely, rod and geared.

Rod Locomotives. — These have the power transmitted from the cylinders to the drivers by means of a connecting rod. They have a longer wheel-base than geared locomotives, consequently they cannot take as sharp curves, but are the best type for a smooth, well-maintained road of easy grade, and because of their speed are especially serviceable for main-line engines when the haul exceeds 7 or 8 miles.

Those used for logging purposes range in weight from 20 to 115 tons. Saddle-tank locomotives of from 20 to 35 tons' weight are often used on spur tracks, and are more efficient for their size than types with a tender because there is less dead weight for the engine to carry. For main-line work locomotives of 40 tons or more are in general use.

A special form of rod locomotive, known as the Mallet Articulated Locomotive, has recently come into use on logging roads that have sharp curves. The essential features are two sets of engines mounted under the boilers, each connected to independent groups of drivers. The rear engine is fixed rigidly to the boiler in the same manner as for the regular pattern of rod locomotive. The forward engine and driving wheels are so attached to the boiler that the truck may have a lateral motion when taking curves. This truck is connected to the rear engine by means of a radial draw-bar and steam is transmitted to the cylinders on the front truck through an articulated pipe. The forward pony truck is pivoted and may swing from side to side, independent of the trucks bearing the engines. The cylinders are

single or compound expansion, and the exhaust steam of the rear engine is used in the cylinders of the forward engine, thus effecting a saving in fuel.

The advantages of this type of engine are that the wheel base is materially shortened by having two separate sets of drivers which permit the use of a heavy rod locomotive on a road having curves that are too sharp for the regular type of rod engine of the same weight; and it is so constructed that live steam may be used in the cylinders of both engines to secure greater power to start loads, which increases the hauling power of the locomotive in comparison with that of an ordinary rod engine of the same weight, since an engine can keep in motion a greater load than it can start. Another feature claimed for this locomotive is that the drivers slip less than on other types of rod engines because the forward engine depends on the rear one for steam, and should the drivers connected to the latter slip, the exhaust would fill the feed pipe of the forward engine faster than it could be relieved and the resulting back pressure on the high-pressure piston would reduce the speed and prevent further slipping.

Locomotives of this type, ranging in weight from 81 to 121 tons, are in use on logging roads in the Pacific Northwest. The minimum weight in which they are built is 50 tons. One weighing 121 tons is in operation on the Pacific Coast on a road having 35-degree curves and 8 per cent grades.[1]

Geared Locomotives. — The first geared locomotive was constructed about 1885 by E. E. Shay, a Michigan logger, and this locomotive, with some modifications and improvements, is in extensive use to-day. Several forms of geared locomotives other than the Shay are now on the market.

The objects sought in geared locomotives are to secure a maximum amount of tractive force with a minimum total weight, a short truck base that will enable the engine to take sharp curves with ease, and a form of truck that will adjust itself readily to an uneven track. These ends are accomplished by making every wheel under the engine and tender a driving wheel; by transmitting power to the driving wheels through a series of bevel

[1] The Timberman, August, 1910, p. 63.

gears that bear a relation to each other of from 2 to 1 or from $2\frac{1}{2}$ to 1; and by the use of swivel trucks on which the drivers are arranged in pairs and connected, one with another, by means of an articulated driving rod. The weight is distributed over a long wheel base which permits the use of a smaller rail, fewer ties, lighter bridges and a poorer track than for a rod locomotive of the same weight.

On poor track where a speed of from 6 to 12 miles per hour, only, is possible, geared locomotives are preferable to rod because they have large fire boxes, short stroke engines, and a high piston

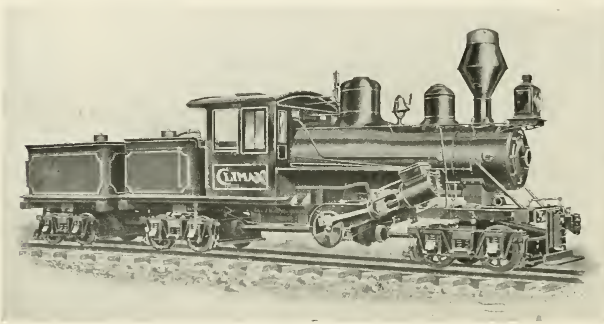

FIG. 86. — A Climax Geared Locomotive.

speed. The slow cylinder speed of rod engines causes defective draft on grades.

There are two types of geared locomotives, namely, the center shaft and the side shaft.

(1) Center shaft. There are several patterns on the market, the ones most commonly used being the Climax and the Heisler.

The Climax is mounted either on two or three four-wheel swivel trucks. When two trucks are used, one is placed under the forward and one under the rear end of the locomotive. When three trucks are used, two are placed under the engine proper and one under the tender. The boiler is of the horizontal locomotive type, mounted on a steel channel frame, reinforced

with truss rods. Two single-cylinder engines are attached to the frame, one on each side of the boiler, and transmit the power directly to a heavy crank shaft, placed under the boiler and at right angles to it. This shaft is held in position by a frame fixed to the boiler, and power from the shaft is transmitted by gearing to a central articulated line shaft which passes to the forward and rear trucks and runs on bearings on top of each truck axle. Pinions fitted on this shaft mesh into gears on each axle and thus transmit power to the driving wheels.

Locomotives of this class are built in weights ranging from 18 to 75 tons. Those of from 18 to 60 tons' weight have eight drivers and those of from 65 to 75 tons weight have twelve drivers.

A Climax locomotive with an upright engine and a "T" boiler is built in 15- and 18-ton weights. The frame of heavy timbers is supported at each end by a pair of swivel trucks. Two vertical high-speed, double-acting engines are located in the center of the main frame and are directly connected to a shaft which carries two spur gears of different sizes, which mesh into two main gears on the center driving shaft. These provide a high or low speed as required. A center shaft transmits power to the driving wheels in the same manner as the horizontal style of locomotive previously described. This locomotive is used on stringer and light steel roads.

The Heisler locomotive is built in weights ranging from 18 to 75 tons. The locomotive and tender are carried on a heavy steel frame mounted on two pairs of swivel trucks, one set being placed under the forward end of the locomotive and the other under the tender.

Power is furnished by two single-cylinder engines attached to the frame one on each side of the boiler. Each is inclined at an angle of 45 degrees from the vertical. The reciprocating parts of the engine are connected directly to a central single-throw, articulated driving shaft.

Spur wheels are fitted to the center of the forward and the rear axles and pinions attached to each end of the driving shaft mesh into them. The spur wheels and pinions are enclosed in

a tight case which is designed to prevent the entrance of grit and other foreign substances.

Heisler locomotives of 35 tons weight cost about $7000 and those of 55 tons weight cost about $9000.

(2) *Side Shaft.* — The Shay locomotive is the only one of this type on the market. It is built in weights ranging from 13 to 150 tons.

The frame is made of heavy steel "I" beams braced with trusses, and is supported on from two to four pairs of four-wheel

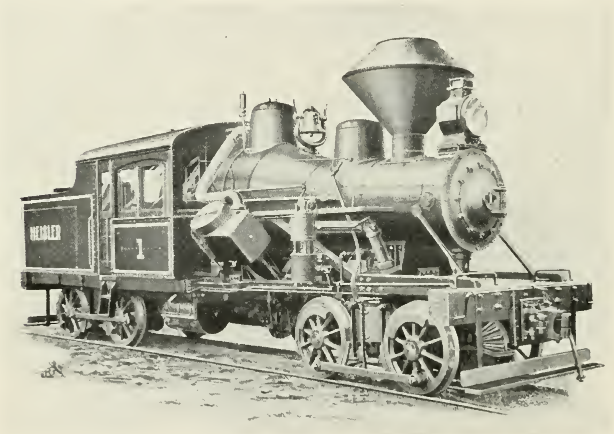

Fig. 87. — A Heisler Geared Locomotive.

swivel trucks. Locomotives weighing 55 tons and less have two trucks; those from 65 to 105 tons, inclusive, three trucks; and the 150-ton locomotives, four trucks. The additional trucks in the two latter are used to carry the tender.

The boiler is of the horizontal locomotive type with extra large fire box and steam space. The engines are of the vertical type and are attached to the boiler plate on the right-hand side just in front of the cab. Locomotives of from 13 to 20 tons weight are equipped with two cylinders, and those of greater

weight with three cylinders, placed side by side and directly connected, 120 degrees apart, to a driving rod which is supported on a heavy bearing attached to the boiler. The driving rod is broken both with universal joints and also with two slip joints to permit either an increase, or a decrease, in the length when passing around curves.

The right-hand wheels on each truck are fitted with gear rims into which mesh the pinions which furnish the driving power for the locomotive.

A 50-ton Shay locomotive, f.o.b. factory, costs about $7500.

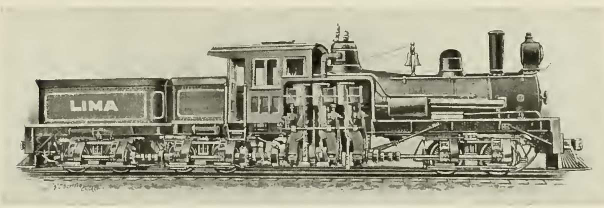

FIG. 88. — A Shay Geared Locomotive.

HAULING ABILITY OF LOCOMOTIVES

The hauling ability of a given locomotive depends largely on (1) the tractive force, (2) the resistance of the load to gravity, and (3) the frictional resistance.

Tractive Force. — The tractive force of a locomotive, sometimes improperly called the "draw-bar pull," is the power possessed by a locomotive for pulling a train, including the weight of the locomotive itself. If one end of a rope is passed over a pulley and fastened to a weight hanging in a pit, and the other end is attached to a locomotive running on a straight level track without regard to speed, the tractive force of the locomotive will be represented approximately by the amount of weight the locomotive can lift. Tractive force increases in direct proportion to the area of piston heads, length of stroke and steam pressure in the cylinders, and decreases directly as the diameter of the driving wheels increases.

Tractive force is dependent on the weight of the locomotive on its driving wheels because it adheres to the rail only by the friction developed between these wheels and the rail head, and the resistance to slipping increases with the weight on the driving wheels. The weight on wheels other than drivers has no effect on the tractive force. If the engine is too light in proportion to its power it will be unable to hold itself to the rail and exert a strong pull, while on the other hand if the weight of the locomotive is too great in comparison to its power, it will not haul maximum loads because of the excess weight in itself that must be moved. In industrial locomotives the economical ratio between the weight on the drivers and the tractive force ranges from $4\frac{1}{4}$ to 1 to 5 to 1; *i.e.*, the tractive force in pounds is from 23 per cent to 20 per cent of the total weight on the drivers.

The usual formula employed for determining the tractive force of single-expansion rod locomotives with a piston speed not exceeding 200 feet per minute is as follows:

$$T = \frac{d^2 \times L \times .85\,p}{D},$$

when T represents the tractive force,

d represents the diameter of the cylinder in inches,

L represents the length of piston stroke in inches,

$.85\,p$ represents 85 per cent of the boiler pressure,[1]

D represents the diameter of the driving wheel in inches.

As the speed increases the tractive force decreases because the mean effective pressure in the cylinders falls and friction also increases.

Resistance to Gravity. — The resistance to gravity increases in exact proportion to the grade and is always 20 pounds per ton of 2000 pounds for each 1 per cent rise in grade; *e.g.*, for a 0.5 per cent grade it is 10 pounds per ton and for a 4 per cent grade it is 80 pounds per ton.

[1] This has been found by practical test to be the average effective pressure in the cylinder.

Resistance due to Friction. — The resistance due to friction varies with the character and condition of the roadbed and the rolling stock.

The resistance of the flange friction of wooden rails is about twice that of steel rails. Poorly laid or crooked rails and overloading increase the rolling friction, which is also greater in cold weather than in warm and greater for empty cars than for loaded ones.

Logging cars of good construction, and with well-oiled bearings should have a frictional resistance of from 12 to 20 pounds per ton of weight handled.

The frictional resistance on curves is extremely variable because it is governed by numerous factors, among which are the degree of curvature, length of the wheel base of locomotives and cars, elevation of the outer rail, speed, condition of rolling stock and track, length of train, and length of the curved section. Frictional resistance is partially overcome by increasing the width of track on curves $\frac{1}{16}$-inch for each $2\frac{1}{2}$ degrees of curvature, and also by coning the face of the car wheels so that the greatest diameter is next the flange. When crowded against the rail the outer wheels will then travel farther, per revolution of the axle, than those on the inner side of the curve. Friction is also developed, because the rigid attachment of the axles to the truck frame does not permit them to assume a radial position with reference to the curve. On a 6-driver rod locomotive the long wheel base is partially overcome by making the center drivers flangeless. On very sharp curves it is customary to lay extra rails inside of the outer rail and outside of the inner rail to provide a support for the flangeless drivers. In determining the amount of frictional resistance due to curves it is the general rule to assume the resistance for standard gauge to be $\frac{1}{2}$ pound per ton per degree. If the wheel base is the same, curve resistance in other gauges is about in proportion to the relation of the gauges.

Calculation of Hauling Capacity. — The hauling capacity of a locomotive in tons of 2000 pounds is determined by dividing the tractive force of the locomotive by the sum of the resistance

due to gravity, rolling friction, and curve resistance, and then deducting from this result the weight of the locomotive and tender. This gives the tonnage the locomotive can haul, including the weight of the cars.

The estimated hauling capacity of locomotives of given weights and types can usually be found in the catalogues of the manufacturers.

The following figures were secured from logging operations. On a 24-degree curve and on a 3.5 per cent grade, two 40-ton Shay engines have hauled six loaded flat cars[1] containing 42,000 feet board measure, while the same locomotives have hauled eleven cars, 77,000 feet, over 32-degree curves and a 3 per cent grade. A 60-ton Shay on the same operation hauled five cars, 35,000 board feet, over a road having 24-degree curves and 3.5 per cent grades; and eight or nine cars, of 7000 feet capacity each, over a 32-degree curve and a 3 per cent grade. A 18-ton Shay, operated on a road four miles long and having grades ranging from 0 to 8 per cent, and with one 47-degree curve handled daily 150,000 board feet.[2] A 50-ton saddle-tank, rod locomotive operated on a road having maximum grades of 2 per cent and curves of 30 degrees has handled eight loaded skeleton cars with safety.

FUEL FOR LOCOMOTIVES.

The fuel used on logging locomotives may be wood, coal, or crude petroleum.

Wood is frequently used in regions where coal and oil are expensive; because of heavy transportation charges, however, it has several disadvantages.

(1) There is danger from forest fires during the dry season because sparks are thrown for long distances. A great percentage of the forest fires on logging operations start along the railroad.

(2) There is a large bulk of material to be handled. It requires twice the amount of wood as compared to average

[1] Length 41 feet; weight of each car 27,000 pounds.

[2] The Timberman, September, 1910.

bituminous coal to secure equal steaming results, and the space occupied by the fuel on the tender is about five times as great. Train crews spend too much time daily in taking on wood which involves loss both for the train crew and locomotive.

(3) When pitchy woods are used it is impossible to maintain an even heat, because the resinous matters are driven off first and the burning gas creates an intense heat for a short period, but before the wood has been consumed sufficiently to permit a new supply to be fed into the fire box, the temperature falls markedly. This alternate rising and falling of temperature causes a constant contraction and expansion of the fire box and tube metal and the latter soon become leaky.

(4) A skillful fireman is required to handle a wood fire so that a sufficient amount of steam may be available at all times, especially on heavy grades.

Bituminous coal is preferred to wood on logging roads where it can be secured at a reasonable price, although it is fully as dangerous from the standpoint of forest fires. It is greatly preferred by firemen because the labor is not so exhausting and a more even fire can be maintained.

Fuel oil has met with much favor where it can be secured at a cost not greatly in excess of other kinds of fuel.

It has the following advantages over wood and coal:

(1) The danger from forest fires is eliminated.

(2) The cost of handling is reduced to a minimum, because the oil may be pumped into the storage tanks on the tender and a sufficient supply carried to run for at least one-half day. The added time saved in taking on fuel as compared to wood is an important item during the course of a month. It is easier to transport oil in supply tanks than it is to handle an equal fuel value in wood or coal.

(3) A saving in fuel and water is effected on heavy grades and the hauling ability increased because the steam pressure can be held at a desired point by increasing the oil feed under the boilers. It is not possible to do this with wood or coal, since merely opening and closing the fire box has a marked effect on the efficiency of the locomotive under strained conditions.

(4) A man can learn to fire an oil-burning locomotive in a few days because no especial skill is required. A saving in wages is therefore effected.

The relative value of the three kinds of fuel is approximately as follows:

One ton of good-grade bituminous coal is equivalent to one and one-half cords of oak wood, or from two to two and one-half cords of softwood, and from 130 to 190 gallons of crude petroleum.[1]

The choice between the different classes of fuel is made either on the basis of forest fire danger or on the relative cost. Some roads passing through forested regions use oil during the danger season and coal during other periods.

The amount of fuel consumed daily by a logging locomotive is extremely variable, depending on the mileage traveled, the loads hauled, the number of heavy grades traversed, and the efficiency of the fireman. A 45-ton Shay on a western operation averaged nine barrels of fuel oil daily at a cost of $8.60. A 37-ton Shay in the same region burned about five cords of softwood at a cost of $12.50. A 54-ton rod engine on a southern pine operation averaged four cords of pine knots per day, and a 55-ton Shay on the same operation burned from two to two and one-half tons of bituminous coal.

The average daily expense for oil, waste, etc., ranges from $1.50 to $2.00.

WATER

Provision is made for watering locomotives either at the mill or at some convenient point along the railroad. Water may be supplied from storage tanks, by gravity pipe lines from streams, or taken direct from the streams by an injector. The amount of water required is a variable factor, depending on the amount of work performed by the engine and the efficiency of the fireman.

Trautwine says that between six and seven pounds of water

[1] Tests on the Boston and Maine, in 1903, showed that from 130 to 140 gallons of crude petroleum were equal to a short ton of Pennsylvania bituminous coal. In 1910 the New York Central and Hudson River Railroad in the Adirondacks found that from 170 to 190 gallons of crude oil were equal to one ton of bituminous coal.

are evaporated for each pound of average grade coal that is consumed. On a basis of $6\frac{1}{2}$ pounds of water (0.8 gallons) per pound of coal, 1600 gallons will be required for each ton of coal, or 800 gallons for each cord of wood consumed. Engines which "blow-off" at frequent intervals will require more water than the amount mentioned.

B. CARS

Logging cars are subject to severe usage and are built chiefly with wooden frames so that repairs can be made at the loggers' machine shop.

NARROW GAUGE

When light rails are employed, the same type of car as described for the stringer-road (page 247) is often used. When a 35- or 40-pound rail is in use a heavier car is desirable. The main features are similar to the 8-wheel stringer-road truck mentioned, but they are built heavier to secure a capacity of from 1500 to 3000 feet, log scale.

BROAD GAUGE

Three types of cars are in use on broad gauge roads, namely, flat cars, skeleton cars, and trucks.

Flat Cars. — These are seldom purchased by loggers but are used where the logs are hauled for a portion of the distance over a trunk line road. The latter usually furnishes the cars, keeps them in repair, and provides motive power when the cars are on its line. Payment for this service is made on the basis of the number of cars hauled, the number of thousand feet of logs handled, or a flat rate per train-mile.

Logging flat cars may have special rails laid on the car floor on which log loaders travel, and also wooden or metal bunks to raise the logs off the car floor.

Standard 40-foot flat cars fully equipped cost from \$850 to \$925.

Logs are held on flat cars by stakes or chains.

(1) *Short Stakes.* — These are made near the loading place by a stake cutter, and are inserted in the stake pockets on the

car. They are usually thrown away at the unloading point. If bunk loads only are hauled and the logs do not occupy the entire floor of the car, the bunks are equipped with adjustable "chock blocks," or dogs, which are fitted to the bunk close to the log; or rough blocks or small logs may be inserted between the logs and the stakes to make the load solid. Where a top load is put on a car, the logs wedge between those on the car floor and make a compact load.

(2) *Patent Drop Stakes.* — These project from 2 to 3 feet above the car floor and are equipped with safety trip devices for use in unloading. The logs are seldom bound with chains unless the load is built high.

(3) *Long Stakes.* — For carrying high loads cars are often equipped with stakes from 5 to 6 feet long, which are cut from saplings or made from sawed material. They are inserted in the stake pockets, and after the greater part of the load has been placed in position the stakes on the opposite sides of the car are bound together with heavy wire, cable, or with chains to prevent the load from spreading at the top. The remainder of the load is then placed on top of the binders. Sapling stakes with wire binds are used where it is not feasible to return stakes and binding material to the forest for further use.

(4) *Chains.* — Logs may also be made secure with binder chains. After the main body of the load has been placed on the car, either a chain is passed around each end of the load, or one chain may be passed around the center. In the latter case corner bind chains are used if the car is not provided with stakes. Each set consists of two chains, one of which is fastened near the center, and the other to the outer end of the bunk. The first chain is about 2 feet long and the free end terminates in a ring, 3 or 4 inches in diameter. The second chain is several feet long and its free end terminates in a grab hook. When the first tier of logs is loaded on the car, the corner binds are adjusted on the two outside logs. This is accomplished by placing the long chain over the log, passing the grab hook and chain through the ring in the short chain, drawing the long chain taut and locking it at the ring with the grab hook. The top load is then placed

and if necessary a center bind placed around the entire load, and one or more logs placed on top of the chain to tighten it.

Flat cars are usually from 24 to 41 feet long. Those 36 feet and over in length will carry a double load if the logs do not exceed 18 feet in length. The average car load, for medium-sized logs, is from 4000 to 6000 feet, with a maximum of about 10,000 feet, log scale.

Skeleton Cars. — This type of car consists of two pairs of 4-wheel trucks joined together by a heavy bolster of oak or pine. A heavy bunk from $8\frac{1}{2}$ to 10 feet long is placed directly over each pair of trucks. Bunks are approximately 11 feet apart on a standard length car, but are also built for long logs with bunk centers up to 33 feet apart.

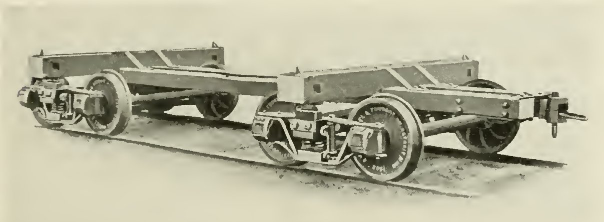

FIG. 89. — A Skeleton Log Car. A type common in the southern pine forests.

Skeleton car bunks are equipped with a variety of stakes and "chocks" for preventing the bottom tier of logs from rolling off.

One end of each bunk is often provided with bunk spikes, bolted to or driven into the wood while the other end is equipped with a chock or dog, which projects above the bunk when in use, but which may be dropped below the bunk level by means of a rod operated from the opposite side when the car is ready to unload. The load is often fastened with a single "top bind" chain passed around the center of the load.

Cars are frequently equipped with patent drop stakes, which project from 18 to 24 inches above the bunk and are held in place by means of chains or bands, which may be loosened by a rod manipulated on the opposite side of the car. Drop stakes

are useful where small and medium-sized logs are handled. They also obviate the use of binding chains. Some operators use round stakes without attachments.

In handling small and medium-sized logs the loads are sometimes built up square and the logs are held by several sets of binding chains and often by a top bind chain. Logs are loaded in this manner by power loaders and a falsework is used on the side opposite the skidway, against which the loads can be built and held in position until binding chains can be placed.

Skeleton cars are equipped either with hand or air brakes, and usually with pin couplers. They range in weight from 6900 to 18,500 pounds each and have a rated carrying capacity of from 30,000 to 80,000 pounds. They will carry from 1600 to 10,000 feet, log scale. The heavier-weight cars are employed exclusively for the heavy timber of the Pacific Coast.

Skeleton cars combine lightness with a maximum carrying capacity, are reasonable in initial cost, and are the cheapest form of car to maintain.

Trucks. — These are used on the Pacific Coast and are especially adapted for long logs.

They consist of two pairs of wheels on which is mounted a steel frame. A steel or wood swivel bunk, 9 or 10 feet long, is mounted on the frame above and midway between the pairs of wheels. The bunk is armed either with steel spikes or with a long sharp strip of steel which prevents the logs from slipping forward or backward.

Trucks are equipped with hand or air brakes; pin or automatic couplers; patent stakes or "chock blocks" for holding the bunk load in place; and chains for binding the load. They are built in a high and a low type, the former carrying the heavier loads. They are in common use on roads operated by loggers, but are seldom operated on trunk lines since they are averse to handling them.

Logs of approximately equal lengths are selected for a given load, and a truck is required under each end of the logs which are chained to the bunks. The rear truck under one log and the forward truck under the following log are coupled together.

The weight of the logs may be sufficient to hold them firmly on the bunk without the use of chains; however, if the train is long and the strain is severe, chains are used. Where the cars are equipped with air brakes, extension air-brake hose is adjusted under the log or logs between the two trucks, and is held in place by chain or rope attachments placed around one of the logs.

Trucks weigh from 10,600 to 13,500 pounds each and have a rated carrying capacity of from 50,000 to 75,000 pounds.

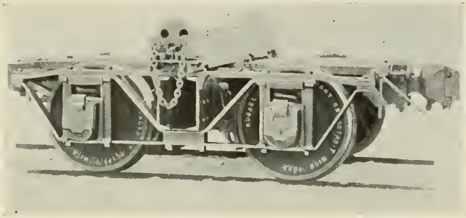

Fig. 90.—A Log Truck of the Type used in the Pacific Coast Forests.

In practice low trucks seldom carry more than 5000 feet and high trucks 7500 feet, log scale.

ROLLING STOCK AND MOTIVE POWER EQUIPMENT

The number of logging cars required on a given operation is dependent on

(1) The amount of timber handled daily

(2) Capacity of the individual cars.

(3) The average number of cars hauled per train load.

(4) Manner of loading and handling cars in the woods. When loading is concentrated in one or a few places, fewer cars are required than where loading is done at various points.

(5) Manner of handling cars at the destination. If the train crew unloads the cars on arrival at destination, the number of cars required is less than where the cars are left to be unloaded while the engine returns to the woods for another train load.

(6) The distance that the cars must be hauled. On long hauls a maximum number of cars are on the road to or from the

mill; while on a short haul the number is less, because of the short time required to make a round trip. The requirements for a large operation having an 8- or 10-mile haul cannot be met unless the number of log cars available is equal to twice the number of loaded cars hauled daily.

The equipment used by a large white-pine logging company operating 14 miles of narrow-gauge main-line and from 2 to 4 miles of spurs, and delivering daily from 200,000 to 210,000 feet, log scale, at the mill was as follows:

154 Skeleton logging cars (24 feet long, bunks 8 feet wide, 10 feet center to center), 3000 feet, log scale, capacity.
2 Cabooses (1 for the main line and 1 for the construction train).
2 Box cars for hauling supplies to camp.
2 Flat cars for the construction train.
2 Water tank cars for hauling the camp water supply.

Thirty-five cars were loaded at skidways each morning and each afternoon, making a total of seventy cars daily. The remainder were on the road or in the repair shop.

Three locomotives only were employed on this road, two for hauling and one for road construction work. One of them, a 60-ton rod engine, hauled only on the main line, while a 55-ton Shay geared locomotive hauled on the spurs and pulled a train for 7 miles on the main line each morning and night. A 35-ton Shay was used exclusively for construction work and for hauling water for the camp.

A logger in the Missouri shortleaf pine region, operating 35 miles of standard-gauge main line and from 15 to 20 miles of spurs, used the following equipment to handle 125,000 feet daily (90 cars)

316 Skeleton log cars, (20 feet long; bunks 10 feet wide, 12 feet center to center).
2 Cabooses, (1 for the main line and 1 for the loading crew).
2 Tank cars for hauling water for the camp.
2 Flat cars (1 for the construction crew and 1 for the main-line train).
1 Mule car for transporting the loading-crew animals.

Seven rod locomotives of the following weights were used:

1	24-ton
1	36-ton
1	38-ton
2	44-ton
1	48-ton
1	50-ton

Five engines were in constant use in hauling on the main line and spurs; one locomotive was used by the loading crew and construction train; and one was held in reserve.

An Alabama longleaf-pine operation with 24 miles of main line, and from 5 to 6 miles of spur used fifty-three forty-foot flat cars to haul daily from twenty-five to thirty cars of logs (70,000 to 90,000 feet, log scale). These cars had a rated capacity of 60,000 pounds and each carried from 2500 to 3500 feet, log scale.

The logs which were hauled 6 miles over a trunk-line railroad, were loaded on cars provided and kept in repair by the trunk-line railroad which also furnished one 65-ton rod engine for use on its track.

The logging company provided one 54-ton rod, one 40-ton rod, and three Shay locomotives of the following weights, 28, 32, and 55 tons. The rod engines were used on the 18 miles of main-line logging road, while the 32- and 55-ton Shays were used on the spurs, and the 28-ton Shay on the construction train.

On a western operation where 200,000 feet were hauled daily over a 3-mile main line with a 5 per cent grade and many curves, a 55-ton Heisler was used on the main line and a 35-ton Heisler on the $3\frac{1}{2}$ miles of spurs. Forty 40-foot flat cars were required to handle the output.

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CHAPTER XXI

LOADING AND UNLOADING CARS

LOADING CARS

The Crosshaul. — One of the early methods of loading cars was by means of the crosshaul (page 141). A crew of five men and a team were required and the daily output did not exceed 40,000 feet. On large operations this method is too slow, although it is still employed by loggers who have a small daily output. The cost of loading by this method ranges from 25 to 35 cents per thousand feet.

Photograph by C. S. Judd.

FIG. 91. — Loading Log Cars with the Crosshaul. Missouri.

Power Loaders. — One of the first successful power loaders was put on the market in 1885 and since that time many forms have been brought out, which differ in the manner of locomo-

tion, character of booms, and other details to meet special requirements. They are used for loading flat or skeleton cars.

The main features of a power loader are a steam hoisting-engine and drums and an upright boiler. These are mounted on a truck provided with some appliance for transporting itself, and also carrying a rigid or swinging loading boom. Gasoline engines have recently been substituted for steam on some patterns, but they are not in extensive use.

Loaders are built with a short swinging-base control boom, a long swinging end-control boom, or with a rigid boom. The first two types are adapted for loading on poor track, because the logs can be centered on the car and less manual labor is required to build the load securely. They also are desirable where the logs are scattered. Short booms are not adapted for handling long lengths. Rigid booms are used to advantage on good track where the logs are abundant and fairly well decked.

There are two types of loaders.

(1) Loaders operating from log cars. The Barnhart, Model C American and the Rapid loaders are the best illustrations of this type.

(2) Loaders operating from the main railroad track. The Decker, McGiffert, Surry Parker, American Models D and E, and the Browning are the more common machines of this type.

An advantage of the Decker and McGiffert loaders is that the loader may remain in one place until all logs are loaded, while loaders of the first type must change their base for every car unless a locomotive is in attendance to move the train as desired.

(*a*) *Barnhart.* — This style of loader requires either permanent or temporary tracks on the log car over which the loader passes. Where permanent track is used, the rails are laid only the length of the car bed, because if they were sufficiently long to permit the loader to span the gap between cars they would interfere when the train rounded sharp curves. The space between the rails on each car is spanned with two ∩-shaped irons placed on the car rails which can be removed as soon as the loader has passed over the gap. Temporary tracks are made in

three sections. The loader rests on one section, another spans the gap between the two cars and the third rests on the empty car in the rear of the machine. As the loader proceeds along the train the tracks are picked up by the loader and moved behind it.

The engine, drums, booms, and all working parts are mounted on a steel frame which is pivoted to a truck frame carrying eight pairs of trucks, with wheels 10 inches in diameter. The loader can revolve in a complete circle by means of a geared wheel attached to the truck frame, into which mesh two pinions

Fig. 92. — A Model C American Log Loader.

which are driven by a double rotating engine. One form of this loader uses a chain control for the rotary movement. The weight of the loader is borne on five cone-shaped rollers attached to the truck frame.

The loader propels itself from one car to another by means of a cable passed around a drum on the loader, with the free end attached by a hook to one of the cars in the rear.

A feature of this loader is a slack pulling device which consists of a pair of friction sheaves mounted on the boom and driven by a belt. The power is controlled by a hand lever.

Two sizes of loaders are made, the smaller, No. 10, having

chain control, an oak boom 25 feet long, a double $6\frac{1}{2}$- by 8-inch hoisting engine with governor control and a 36- by 96-inch vertical boiler. The cost of this loader is $3500 f.o.b., Marion, Ohio.

The No. 12 loader has a steel boom 23 feet 9 inches long, gear and pinion rotary control, double hoisting engines with $7\frac{1}{2}$- by 8-inch cylinders, controlled by a balanced throttle, and a 50- by 82-inch vertical boiler. The pull at the tongs on this machine is claimed to be from 9 to 10 tons. The cost of a loader of this type is $4700 f.o.b., Marion, Ohio.

FIG. 93. — The Rapid Log Loader.

The Barnhart, though a fast machine, is more expensive to keep in repair than some of the other types of loaders, and requires skillful labor to secure the maximum output. Many loggers do not regard it with favor for use on narrow-gauge roads. The maximum log that it can handle is one containing about 1500 feet log scale.

(*b*) *Model C American.* — This type of loader is similar in character and operation to the Barnhart. It runs on temporary tracks and uses the geared circle for rotating the machine. It is one of the cheapest loaders to keep in repair and will handle a log containing 2000 feet log scale.

It costs from $4000 to $4500 depending on the number and character of special attachments.

(*c*) *Rapid.* — The Rapid loader is a stiff wooden boom machine, with an upright boiler and double hoisting engine. These are mounted on a pair of steel runners on which the loader slides from car to car. Power for moving itself is furnished by a cable and drum. Rapid loaders are sometimes mounted on a heavy pair of two-sleds for sled loading. It is adapted for light work.

FIG. 94. — A Decker Log Loader.

(*d*) *Model D American.* — This loader is used only where light equipment is employed because it is necessary for the loader to lift the empty car from the track in the rear to the front, or vice versa. Model E is similar in character but has eight wheels on the trucks and is adapted for poor track. Both D and E can move under their own power. Model D costs about $4900.

(*e*) *Decker.* — The frame of this loader consists of two decks. The upper one is supported by steel posts which rest on bolsters placed directly over the trucks on which the loader is mounted. This deck carries the boiler, engine, and other working parts of the machine, while the lower deck is on a level with the bolsters

and carries a portable track with hinged end sections which may be lowered onto the rails and thus provide a continuous track through the loader.

In operation a train of empties is pushed out to the loader and backed through it until the last car comes in proper position, under the boom, for loading. As other empty cars are required a cable connected to a drum is run through the machine and is attached to the draw bar of the first empty car. This car is then hauled through the loader, pushing the loaded car forward

Fig. 95. — A McGiffert Log Loader.

until the succeeding empty one is in position for loading. The work proceeds in this manner until the skidway has been emptied.

The Decker can travel under its own power from one point to another, and can switch cars if necessary, although the latter is not economical if a locomotive is available. It is recommended for narrow-gauge steel and wooden railroads. The Decker loader costs from $4500 to $6000.

(*f*) *McGiffert.* — This loader is similar in operation to the Decker. It has one elevated deck which carries the working parts and when the machine is loading the frame is supported on four corner posts or "spuds" which are curved in toward the

lower extremities. Each post ends in a broad shoe which rests on the crossties outside of the rail. The empty cars pass under the deck, traveling on the main track. The loader is equipped with a pair of trucks at both the forward and the rear end, on which the loader travels. The frames to which these trucks are attached and the trucks themselves are so hung on a shaft under the floor of the deck that during the loading operation they may be brought to a horizontal position under the loader. The machine is then supported on the ties by the spuds. When ready to move, the weight of the loader is lifted from the spuds by bringing the truck frames to a vertical position by means of cables and other mechanism. This raises the loader off the spuds ready for a change of base. Power is transmitted to the axles of the trucks by means of sprocket chains.

This machine is adapted for longer logs and wider-gauge roads than the Decker, because of the greater space between the rail and the deck.

The McGiffert loader costs from $4500 to $6000.

(*g*) *Surry Parker.* — This loader embodies the same general principles as the two loaders previously mentioned, having the upper deck high enough to permit loaded flat cars to run under it. An early type was built without a device for transporting itself, being carried about on a flat car. The modern type of machine, however, is portable, the power being transferred from the engines to the axles by a chain drive.

Capacity. — The output per day of a given type of loader is dependent largely on the skill of the operator and the loading crew, provided logs are at hand and the supply of empty cars is adequate. The daily output may be as low as from 30,000 to 40,000 feet and again may rise to nearly 300,000 feet. For short logs the swinging-boom base-control type of loader is the more active and under average conditions may load from 100,000 to 130,000 feet daily.

Cost of Operation. — The cost of operation per thousand feet, log scale, depends on the daily output, the wage scale of the region, and the price of fuel. The general range is from 18 to 35 cents per thousand feet.

SPECIAL LOADING DEVICES

A number of special devices are used for loading large logs on cars, especially in the Pacific Coast region.

The "Gin-pole." — This is a modification of the crosshaul, a yarding engine being substituted for horses. A $\frac{5}{8}$-inch loading cable passes through a block attached to a mast or gin-pole about 20 feet long, which is set in the ground on the side of the track opposite the landing, and is thoroughly braced with guy ropes.

The logs are loaded from a landing along the railroad to which logs are brought by a yarding engine, road engine, or by a locomotive. Landings are built level with the car bunks and are made from 40 to 300 feet long, but they usually are about 120 feet long to accommodate two 60-foot logs. They may consist of a number of skids from 15 to 18 inches in diameter, placed about 6 feet apart at right angles to the railroad track, and supported on cribwork; or a large log may be placed on the fore part of the landing parallel and next to the track and from this the main skids supported on a cribwork run at right angles. The rear of the landing may be at a lower level than the part nearest the track.

Where top loads are put on cars a "lead log" is placed parallel to the tracks on the side opposite the landing. It projects slightly above the top of the car bunks and in order that the direction of pull may always be at right angles the loading cable is made to pass through the lead blocks which are attached to this log. Where a lead log is not used it is customary to set upright posts 20 feet apart along the track opposite the landing. These are not as convenient as the former because their use makes it necessary for the engineer of the road engine to always leave the logs opposite them.

The loading cable passes from the drum on the road engine, or from a special loading engine through a block at the peak of the gin-pole, then through the lead blocks, then across the car and over and under the center or end of the log to be loaded. The cable is then brought forward and the grab hook on the end

of the cable is caught in the edge of the landing, or on the car bunk. By winding in the cable on the drum the log is rolled up the landing and onto the car.

A modification of this device has been brought out for more rapid work and for handling long logs. It consists of a loading engine similar in type to the yarding engines and two gin-poles and loading lines instead of one. The cables are attached to the logs by means of tongs or slings. Each line may be operated independently or the two may be operated in unison.[1]

Loading with Jacks or Peavies. — This method is used where logs are loaded by hand and only bunk loads are placed on the cars, peavies being employed for loading small logs and jacks for large ones.

Landings with a slight pitch toward the track are used when loading by this method. The cars are spotted opposite the loading point and the logs are put into position to roll onto the car by moving one end or the other of the log with jacks. When the log is in position the blocks holding it are released and the log allowed to roll by gravity toward the car. If it is a small log it may be allowed to roll directly onto the car, but if it is a large one it is stopped on the edge of the landing by chock blocks and then gradually rolled onto the car bunks. Logs are prevented from rolling off the far side of the car by chock blocks fastened to the car bunk. When necessary the distance between the car bunk and the edge of the landing may be spanned by a skid 3 or 4 feet long and 6 or 8 inches in diameter. Four men with jacks can load about 100,000 feet daily.

Loading Logs from Water Storage. — Landings may be replaced by artificial ponds in which the logs are dumped when brought in by the road engine.

A scheme sometimes employed is to run a car into the pond until it is submerged, when a bunk load is floated in position over the car, which is then pulled out loaded.

Another method consists in the use of a modified crosshaul. A lead log is placed at the height of the car bunk on the loading side of the railroad track, and from it skids slope down to the

[1] The Timberman, December, 1910, p. 33.

bed of the pond. Two cables are attached to the lead log at a distance apart of approximately 20 feet, the free ends being fastened to a ring, thus forming a "parbuckle." The loading line which has a hook on its free end, passes from the engine over the load and is caught in the ring of the parbuckle. The latter is dropped down in the water and men standing on a platform a few feet from the edge of the pond float logs over it. The loading line is then reeled in on the loading drum and the logs are rolled up the rollway and onto the edge of the car bunk.

They are drawn to the far side of the car by passing the loading cable over and under the log and catching a swamp hook on the far side of the car bunk. The tightening of the cable rolls the log in the desired direction. The loading line and parbuckle are returned to the pond men by a haul back line. From three to four men can load 100,000 feet per day, in this manner.

Jack Works. — Where logs are to be raised to a considerable height as from a river or a large pond an outfit called a "jack works" is employed. This method has been used both in the South and in the Northeast, where medium-sized logs are handled.

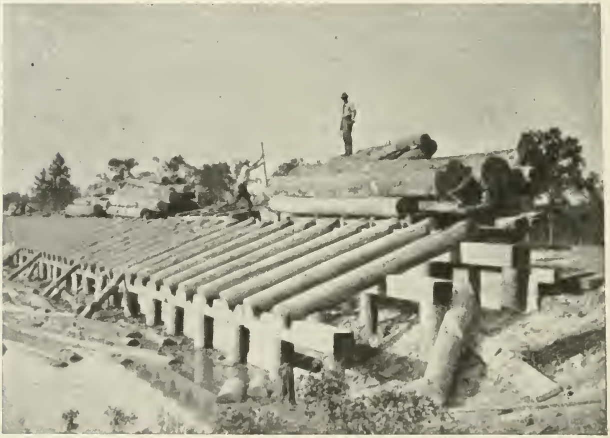
A jack works is a long narrow platform built at a sufficient height above ground to permit the construction of a sloping dock on the side next to the loading tracks, the base of which is flush with the car bunks. The loading tracks on which the log cars are "spotted" are placed alongside the dock. The length of the platform is governed by the number of cars to be loaded and the switching facilities. If provision is made for moving cars by gravity and the logs are of fairly even length so that any of them will go on a given car, the platform need only be long enough to handle the longest logs. When logs must be sorted before loading and when many cars must be spotted at one time the platform should be of sufficient length to accommodate the maximum number of cars.

A shallow trough runs the entire length of the platform. In it an endless chain travels to which log dogs are attached at approximately 8-foot intervals. A similar trough and chain

serve to carry the logs from the water to the platform along which they are carried until they are rolled onto the dock below. The chains are driven either by a steam, or gasoline engine. The logs are loaded on cars chiefly by gravity. Skids are placed from the docks to the load as the latter is built up, and the top logs are rolled on to the load with cant hooks.

UNLOADING LOG CARS

The expeditious unloading of log cars is an important factor in train operations because it reduces the amount of rolling stock required. Logs are generally stored in ponds, streams, or on storage skids, but at hardwoods plants and pulp mills they are occasionally placed in large piles.



Photograph by J. H. Fahrenbach.

Fig. 96. — A Rollway at the Mill Pond. Texas.

Rollways. — Where water storage is used the track is built along the bank of the stream or pond, or else extended over the water on piling. In the former case it is necessary to construct an inclined rollway over which the logs may be rolled into the

water. This consists of a framework composed of three parallel sets of stringers, spaced 8 feet apart, which extend along the water's edge for from 400 to 600 feet. The outer stringer projects over the water's edge and is supported on piling or on timbers that rest on solid bottom, while the other stringers are supported on round or square uprights placed from 4 to 6 feet apart. Heavy round or square timbers, often shod with railroad iron, are placed on top of and at right angles to the stringers, and serve as a bed over which the logs are rolled. These timbers are spaced from 4 to 6 feet apart on the stringers and have a pitch of from 15 to 25 degrees. The upper ends are placed level with the top of the car bunks.

When the water is shallow near the rollway, the logs are shunted into deep water by sloping skids which extend from the lower stringer to the bed of the pond or stream.

The railroad track is laid parallel with the rollway and close enough so that the top of the car bunks will be about 6 inches distant. To facilitate unloading, the outer rail is elevated from 12 to 15 inches thus throwing the side of the car next the rollway at a lower level. Many of the logs will roll from the car into the pond when the car stakes are removed, the dogs on the car bunks lowered, or the binding chains loosened. The remainder of the logs are rolled off the car by means of cant hooks or peavies. This is one of the simplest methods and is widely used in the Lake States and southern yellow pine region where the timber is of medium size.

On the Pacific Coast where logs are often unloaded into tide-water and rafted, the track is built on piling either over the water or else along the side of the bank. The structure is long enough to accomodate twenty cars or more. Some protection must be given the piling supporting the track and when the trestle is in deep water this is accomplished by driving a pile at the end of each tie. These piles are cut off about two feet below the level of the track and are beveled on top to shunt off the falling logs. An additional row of piles is sometimes driven just outside the first one and beveled off in a similar manner. When the trestle is located on land, a slanting roll-

way must be built out far enough to carry the logs into deep water.

The outer rail of the track is elevated from 8 to 12 inches, either by leaving the outer legs of the trestle longer, or by elevating the outer ends of the crossties by means of blocking.

When car stakes are used the practice is either to knock them out with a maul, or to cut them off with an ax. Logs often will roll off the cars unaided, but when assistance is required, jacks are used for log trucks and often for flats. Power unloaders of the character described on page 336 are in occasional use for unloading flats and skeleton cars.

For dry land storage at mills, skidways are built on one or both sides of the device used for conveying logs into the mill. The skidways are wide enough to hold one car of logs, and long enough to accomodate the required number of cars.

Storage skidways consist of a series of parallel skids placed at right angles to the railroad track, and supported on timbers placed on the ground. The skids slope toward the center at an angle of from 10 to 12 degrees to facilitate handling the logs. The outer rail of the track is elevated to aid in unloading.

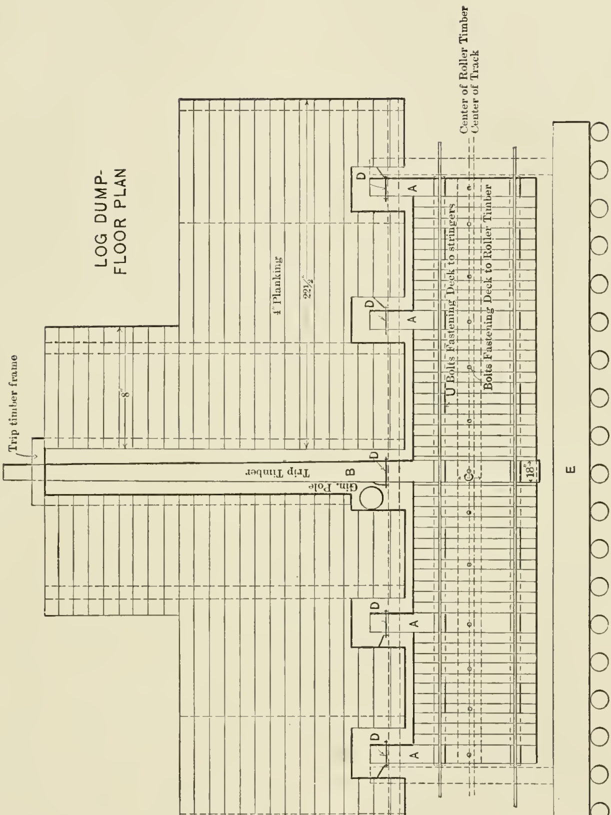
Power Unloaders. — There are several types of power unloaders used which are employed chiefly on the Pacific Coast where large and long logs are handled. However, some types are used in the Lake States and in the hardwood region.

Swinging-boom log loaders which pick logs from the car and deposit them on either side of the track are among the devices used where logs are stored in piles on dry ground.

An overhead cableway system, supported on two spars from 500 to 600 feet apart and spanning the railroad track on which the logs are brought in, is another scheme employed where logs are stored in piles. The trolley is operated in a manner similar to the overhead cableway logging system (page 198).

An ingenious device called a log dump is used at some plants. One built in Washington consists of two dumps separated by 30 feet of stationary track, the entire structure being supported on piling.[1] The platform of each dump is 40 feet long and

[1] The Timberman, August, 1912; p. 68.



Adapted from the Timberman.

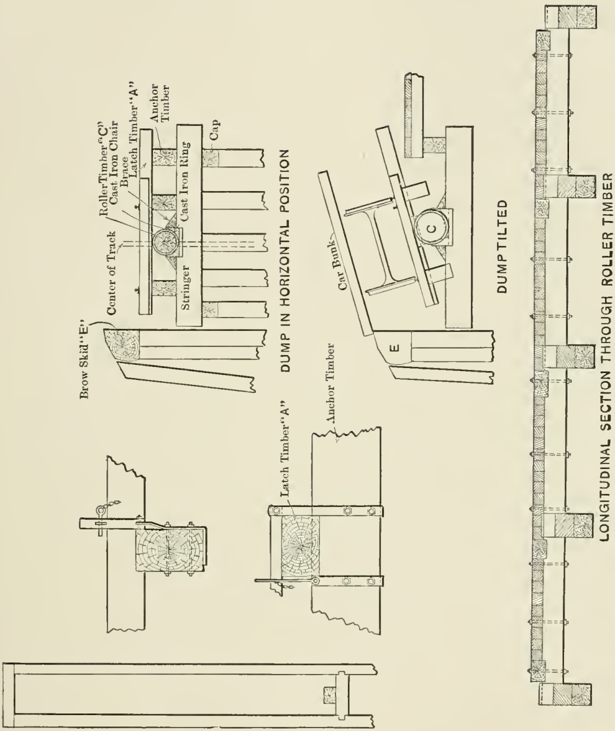
FIG. 97.—Floor Plan of a Tilting Log Dump.

consists of four latch timbers (*A*), which are 11 feet long and a fifth timber (*B*), known as the trip timber, which is 36 feet long and of larger size. The frame is hung on a roller timber (*C*) 18 by 18 inches square and 40 feet 2 inches long which rests on heavy cast-iron sills. The roller timber is bound with an iron cylinder to facilitate its rotation. This roller is placed off-center, the distance between the rail on the land side and the center of the roller timber being 25 inches. When the latches (*D*) holding the frame are released the weight of the load will automatically tip the frame toward the brow skid (*E*) through an arc of 15 degrees. In operation, the cars are run on the dump, the chains holding the logs on the cars removed, and the latches (*D*) opened. The dump then revolves until the car bunk rests on the brow skid (*E*). The majority of the logs will roll off, although some must occasionally be started by means of a cable which passes through a block rigged on a gin-pole. The cable is pulled by a locomotive. The dump will not tip when the load is heaviest on the land side, in which case it is operated by prying up on the end of the trip timber (*B*). After the logs are off the car the dump is brought to a horizontal position by having men walk out on the trip timber (*B*).

The double dump will handle two cars of 40-foot logs, or one car of long logs by spotting one truck on each track. Three men can unload a car in two and one-half minutes and can unload 350,000 feet or more daily.

The cost of the dump was $2000, exclusive of the value of the timber used. Including the cost of rebuilding the dump, the annual repairs during the last seven years have been $300.

An efficient unloader consists of a hoisting engine and two drums mounted on a car equipped with a rigid boom. The railroad track is built parallel to the rollway and the unloader runs on an additional track on the land side of the dump. The boom is so placed that it projects at right angles over the far edge of the railroad track. The unloader can travel back and forth under its own power for a distance of from 500 to 600 feet, thus permitting an entire train to be unloaded without moving the cars. A $\frac{5}{8}$-inch cable passes from the drums on the hoisting



Adapted from the Timberman.

FIG. 98. — Details of a Tilting Log Dump.

engine through a block on the peak of the boom, down under the logs and the grab hook is caught on the bunk of the car or on the buffer log of the rollway. The winding up of the cable crowds the logs off the car onto the rollway. Two other drums and cables are used, one for raising and lowering the boom and the other for moving the unloader back and forth on the track.

Another form designed to unload heavy logs from cars while the train is in motion consists of two steel arms 17 feet long made of channel and angle iron. The arms are 18 inches wide except at the ends, where they are made 36 inches wide to give a broad surface to repel the logs. A heavy casting carrying a sharp edge is attached to the outer end of each arm. The two arms are bolted opposite each other on a 24-inch journal, and are braced with a turnbuckle. The arms and journal are set on a shaft 11 feet long, and 10 inches in diameter, cut down to 8 inches where the journal is fastened to admit the attachment of a collar with ball bearings. The shaft is set in a concrete base, high enough to allow the arms to clear the car bunks, and far enough distant so that when the arm extends across the track at right angles, it reaches one foot beyond the outer rail. To unload a train load of logs, the loaded cars are pushed up to the rear of the unloader, a loader arm is swung up against the log, and the train put in motion. The sharp edge of the arm grips the log and as the train advances the arm is turned on its axis and the log or logs are gradually shoved off the car. The momentum acquired in performing the work causes the arms to revolve rapidly on the axis as soon as the logs are dumped, and the opposite arm comes in contact with the logs on the succeeding car. It is seldom necessary to stop the train during the unloading process. The average time consumed in unloading 75,000 feet of logs from 15 cars is eight minutes.

An unloader similar in type is called the Hercules Log Unloader. It differs mainly in having one arm only and requires the services of a man to attach the arm by means of a chain and grab hook to the bunk of the log car in order to swing the arm across the track. On releasing the chain the arm auto-

matically assumes a position parallel with the track, ready for the following car.

A satisfactory device used by a redwood operator in California for unloading logs from cars consists of a 20- by 28-inch timber, placed across the track at an angle of 45 degrees, and securely fixed at each end on solid supports. The base of the beam is about 8 inches above the upper face of the car bunk. The loaded train, one log on each car, is brought in from the woods and pushed along the track toward the unloader. The logs striking the slanting timber are pushed off the car as the train advances. When half of the train has been unloaded the locomotive is uncoupled from the rear of the train, run around and attached to the forward cars, and unloading is continued until completed. Thirty thousand feet of logs can be unloaded by this device in three minutes.

BIOGRAPHICAL NOTE TO CHAPTER XXI

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PART IV

WATER TRANSPORT

CHAPTER XXII

FLOATING AND RAFTING

Nearly every large stream in the forest regions of the United States has at some time in its history served as a highway down which logs and lumber have been floated to sawmills and market. It is still the favorite method of transporting logs in the eastern part of the United States, but in many other regions it has been superseded by railroads, because of the exhaustion of the timber supply near driveable streams, the extensive logging of non-floatable species, and the increased value of stumpage.

In the more recently developed timber sections of the Inland Empire and the Pacific Coast, water transport early gained a foothold but is now of secondary importance, except where logs are brought to the shores of Puget Sound, the Columbia River and the Pacific Ocean, and then rafted and towed to the mill. In the Northwest the use of small streams for driving is not satisfactory because of the large diameter of the logs and the long lengths in which it is desirable to bring them from the forest.

Logs may either be floated singly or rafted. The former method is practiced always on rough water and small streams, and whenever permissible on large ones; however, rafting is compulsory on navigable streams.

Water transport is primitive, but it is a cheap method of moving logs for long distances where a low expenditure is required for stream improvements and driving, and also for transporting logs out of a well-watered region where otherwise a large mileage of expensive logging railroad would have to be constructed to tap a trunk line.

Water transport has the following disadvantages:

(1) It is limited chiefly to logs which will float. Softwoods and hardwoods are often associated together in the forest and

present market conditions make it profitable to remove some or all of the latter, which is often impossible with water transport.

(2) It is dependent on an abundant rainfall to flood the streams. During seasons of drought it may be impossible or very expensive to move logs by water. This results in a short log supply and the closing down or short-time operation of sawmill plants. Sawmills in the northern regions that are dependent on water transportation for a log supply can only run for six or seven months, unless special provisions are made for keeping the log pond open during freezing weather.[1] During the remainder of the year the plant is idle and during this period the owner does not realize on his investment.

(3) There is a heavy loss in driving logs for long distances. Logs of all species that have much sapwood suffer a heavy loss in merchantable volume between the bank and the mill if they do not reach their destination during the season in which they were logged, because the sapwood is attacked by insects and fungi. Basswood logs that have floated for a short period in water containing vegetable matter acquire a peculiar and unpleasant odor that renders the lumber from them unfit for sugar barrel cooperage and packages for other commodities that are easily tainted.

The heartwood of stranded logs, especially of hardwoods, suffers from checks and splits when exposed to the weather.

A very appreciable loss in driving timber is due to sunken and stranded logs. The extent of this loss is dependent on the species driven and the character of the stream.

Where timber is brought down rough streams, over waterfalls, and past obstructions it is often badly battered and broken, and gravel and sand become imbedded in a large per cent of the logs. Occasionally they accumulate iron and spikes, especially where iron dogs are used in rafting. Much of this foreign matter is not readily detected, and mills suffer a monetary loss due to damaged saws and time lost by the sawmill crew.

[1] The sawing season in the North, on the Mississippi river, with slight fluctuations, is from May 1 to November 1.

Strict laws are now in force in most states providing adequate penalties for the theft of logs so that this evil has been largely remedied. Formerly theft was common on the Pacific Coast, but is now confined largely to logs in the booms tied up at the mills or other storage places.

The actual loss in log scale from all causes on the Mississippi River drives averages about 10 per cent; on the Cumberland and Tennessee Rivers in Kentucky, 10 per cent; in Montana, 10 per cent; spruce, 5 to 10 per cent and birch, 3 to 27 per cent on short drives in the Northeast; hardwoods in Pennsylvania, 25 to 40 per cent; yellow pine, 20 to 33 per cent. The loss in the Lake States may be as high as 30 per cent.[1] On short drives of coniferous timber the loss is small and may be from zero to 3 per cent. This loss is due largely to sunken and stranded logs and not to the deterioration of sapwood.

Floods and storms have caused heavy losses to lumbermen who operate on the large streams.[2] Booms break and loose logs are carried past the mills and deposited on the banks at points below, or carried out to sea. Where logs are deposited on lands adjacent to the streams heavy expense is incurred, not only in getting the logs back in the stream but in the payment of damages to owners on whose property the logs were deposited. It seldom is profitable to return logs upstream to the mill and they are often sold at a sacrifice to mills below.

Many states have passed laws regulating the fee that parties

[1] In the case of James L. Gates *vs.* Elliott C. Young, lumber inspector of District No. 2, Wisconsin, tried in the courts of LaCrosse, Wisconsin, in 1901, an attempt was made by plaintiff to compel defendant to reimburse him for difference in scale between the "bank" and the boom. During the trial, prominent lumbermen from the Black River district testified that "there might and would occur a difference between the woods and mouth scale of from 10 to 30 per cent."

[2] Notable instances are the floods on the Susquehanna River in Pennsylvania, that caused great loss to operators at Williamsport. In 1860, 50,000,000 feet of logs were carried away, followed in 1861 with a loss nearly as great. In 1889, 300,000,000 feet were carried down the river but a considerable quantity of logs were salvaged. Another flood occurred in 1894, when 150,000,000 feet were strewn along the river from Williamsport to Chesapeake Bay. Although many logs from these floods were recovered, the loss to the owners was nevertheless very great.

Floods on the Penobscot River in Maine in December, 1901, carried to sea about 7,000,000 feet of logs, valued at $100,000.

may charge for catching stray logs that are afloat, and the conditions under which log catchers may operate.[1]

Runaway logs on the Ohio River have been carried to the Gulf of Mexico. On many other streams draining into the Atlantic and Pacific Oceans logs have been carried to sea and lost. Timber caught on the high seas is the property of the finder. Rafts on the Great Lakes are sometimes broken up during storms and the logs scattered over the beach for many miles. The collection of logs under these conditions is expensive and in some cases the cost is prohibitive.

(4) Stream improvements are of little or no value after the abandonment of logging operations. The improvements made on streams to render them driveable are often costly and of such a nature that they cannot be used for other purposes after logging is completed. Exceptions to this may be noted in the case of the boom sticks used for storage purposes at large sorting centers, which are manufactured into lumber at the conclusion of operations; and of dams on large streams which may be retained for the control of the water supply.

(5) The heavy and long time investment required for mill stocking. With long drives that are now made one or more seasons may elapse before the logs reach the mill. On the Ohio and Mississippi Rivers it is not uncommon for logs to reach their destination the second summer after cutting and in some cases delivery has been delayed from three to five years.[2] This long time investment in stumpage and logging expense is

[1] The legal fee in Pennsylvania is 50 cents for each thousand feet, log scale, held and delivered to the owner.

The legal fee on the Guyandotte River in West Virginia and Kentucky is 25 cents per log.

A stringent State law in Washington forbids anyone catching runaway logs without permission. This law was found necessary to stop the practice of setting logs adrift from booms at night and then claiming a fee for returning them. Loggers pay 5 cents per tie and 50 cents per log for all runaways that are caught and returned to them.

[2] In 1907 a drive of yellow poplar logs came down the Ohio River from the headwaters of one of the tributaries, where it had been held up for five years because of an insufficient water supply. The loss in merchantable contents of many logs was 75 per cent.

not only a serious drain on the finances of a lumber company but the value of the logs that have been cut for such long periods is greatly depreciated.

(6) The legal complications with riparian owners. The rights of loggers on "floatable" and "navigable" streams are defined by state laws which vary in different states. The driver of logs is liable for damages to property of riparian owners caused by the creation of artificial freshets that overflow the lands, damage the banks, or deposit logs or débris on the property. Navigable streams must be kept open and the rights of all other lawful users of the stream respected. Loggers, in some states, find themselves frequently forced into costly litigation and this has a deterrent effect on the utilization of streams for the transportation of logs.

REQUIREMENTS FOR A DRIVEABLE STREAM

(1) The size of the stream. The stream channel should be wide enough and deep enough to float the largest and longest logs without the formation of jams. High banks are desirable since they confine the water and prevent it from losing its force. When not so confined sufficient water may not be available to float logs for more than a short distance, in which case numerous splash dams have to be built.

The most economical use can be made of a small stream when it is only a little wider than the longest logs and of a sufficient depth to float them clear of all obstructions. If there are obstructions the channel must be capable of improvement at a moderate cost. On large streams logs may be guided around obstructions by the use of booms and other improvements, but in narrow channels this usually is impossible and the stream bed must be improved either by the removal of obstructions, changing the course of the stream or putting in sluices for transporting logs around places where floating by ordinary means is not possible.

(2) The channel must be reasonably straight so that logs will not become jammed at the bends of the stream. This is most important on small streams because of the narrow channel.

Oxbows or curves in small streams may be remedied by making a cut-off or channel connecting the two nearest points, but this is too costly where bends are numerous.

(3) There must be a sufficiently large drainage basin above that part of the stream used to ensure an adequate supply of flood water. Coupled with this there must be storage reservoirs for holding water in reserve for flooding the stream. In the North the snow on the watershed may melt and a large part of it run down the streams before the drive begins. Storage basins are necessary to conserve this water.

Lakes form an admirable reservoir and when available are employed for this purpose. Surplus water is caught and held in them by placing dams across their mouths and when several lakes are tributary to one stream driving may proceed long after the natural spring freshets are over.

Sites for dams should have a narrow channel, high banks and a solid bottom for their foundation. In order to store the greatest amount of water they should be built at the foot of a lake, at the end of a long stretch of dead water, or in such a place that the maximum amount of water can be stored with a minimum of dam height.

Storage reservoirs should be large enough to permit log driving for a minimum of five or six hours daily and the drainage area should furnish enough water to again fill the storage basin before the driving period on the following day.

The required watershed area and the capacity of the storage basins for a given stream are dependent on:

(*a*) The amount of moisture precipitation on the watershed, especially during the fall and winter months, and also the rapidity with which it is made available in the spring. Drives are geneially dependent on flood waters and a rapid run-off is desirable because the storage basins will then be refilled in the minimum time after each splash.

The determination of whether a watershed is capable of supplying sufficient flood water for driving purposes is a matter of judgment on the part of the logger. He bases his conclusions on the flood marks such as flood wood and earth deposits which

are visible along the stream banks, on a familiarity with similar streams, and on a general knowledge of rainfall and floods in the vicinity. The amount of water available for driving in a given watershed usually cannot be accurately determined since specific records from which to draw conclusions are seldom available.

Evaporation may play an important part in influencing the water supply during the summer season by taking moisture both from the soil and from the surface of the storage reservoirs. The water supply for early spring driving is not greatly affected by evaporation, but shallow reservoirs that store water for summer driving have a high rate of evaporation and it is sometimes impossible to collect a head of water.

(*b*) The quantity of water required in a given time to carry logs down stream between storage reservoirs. On small streams where large quantities of water are not available or where the banks are low and the water leaves the main channel it may not be possible to drive logs more than a few miles at most before the force of the water is spent. In such cases frequent storage basins are required.

(*c*) The length of time for which flood water must be available. If artificial freshets are required only for a short time in the spring when the streams are fed from snow water a smaller storage area may be used than when water must be available for several months.

DAMS

Dams for logging purposes are usually built of round timber secured close to the dam site.

It is necessary to construct a dam on solid bottom or bedrock because if this is not done water will work underneath the sills and ultimately cause the structure to go out.

There are three types of timber dams used for logging purposes: (1) the crib or pier dam; (2) the rafter or self-loading dam; (3) the pile dam.

Concrete dams of large size are occasionally used by lumber companies, but they are built by engineers, and loggers are seldom concerned in their construction.

Timber dams on small streams usually have a sluiceway through which logs are run and waste water passed, while on large streams several waste gates are required to take care of surplus water. "Roll dams" which have no gates or sluiceways are also built to raise the stream level. The water and logs pass over the crest of the dam.

Crib Dams. — The crib dam is a common form and is so-called because the buttresses and wings are built of cribs usually filled with stone to hold them down. The necessity for the use of stone is determined by the head of water carried and by the size of timber used in construction. Crib dams are made from round timber hewed on two sides, or from squared timber.

The foundation of a crib dam must be solid and, whenever possible, it is built on bedrock; but if this cannot be done the foundation may rest on piles driven into hard clay or to bedrock. If this is impossible, a row of 3-inch plank or small hewed poles sharpened on one end are driven in a row across the stream channel just above the upstream mud-sill. These planks and timbers are called toe-spiling.

If there is much water on the stream bed it is diverted to one side by temporary dams made of sand bags or by the construction of sluices made from logs or lumber.

In constructing a dam whose sills are to rest on bedrock, the first work done after the water is diverted is to excavate trenches from 4 to 5 feet wide in which the logs forming the cribwork are to rest. The foundation may be made slightly convex on the upstream side in order that the force of the water will tend to tighten the joints of the dam. Three parallel lines of large logs called "mud-sills" are placed across the stream from bank to bank, each row being spaced 6 or 8 feet from the adjoining one. If the dam is to be of greater height than 12 feet, additional sills must be used. The mud-sills must lie flat on the bottom and if possible should be fastened to bedrock with $\frac{3}{4}$-inch drift bolts. A row of cross-skids from 12 to 16 inches in diameter is laid 8 feet apart across the mud-sills in a direction parallel with the stream bed. They extend from the front to the rear

row of mud-sills into which they are notched so as to rest firmly. Logs with two hewed faces are then placed on top of the cross-skids to which they are drift-bolted. These lie parallel to the mud-sills. All timbers on the upstream side of the dam are hewed down and fitted to each other so that a tight face is made.

A cribwork is built up until it reaches the level of the stream bed, when it is necessary to provide a "sluiceway" through which logs may pass and also gates through which surplus water may be wasted. Sluiceways are generally from 9 to 15 feet wide and are placed in the center of the natural stream bed. A sufficient number of waste gates are placed on either side to care for the surplus flood water. The slides of the sluiceway and of the waste ways, both of which carry headworks for gates, are made stronger and of larger logs than the rest of the structure and are often reinforced with piers. In building waste gates and sluices the transverse sills are cut off where the opening begins and the cross-skids which form the side walls of the sluice have smooth hewed faces that fit closely together. The cribwork of the dam is then continued to the desired height. When finished the upstream face of the dam is calked with tow or boarded up with 3-inch plank to make it tight. The cribs are often roughly floored with puncheons and filled with rock to weight them down. The cover of boards on the face is sometimes replaced with a bed of gravel although both boards and gravel are frequently used.

Piers are often constructed on each side of the sluiceway above the dam to confine the water, strengthen the dam, and prevent the structure from being undermined.

An apron also extends out from the sluice on the lower side of the dam to carry the water and logs away from its base and prevent the wearing away of the earth around the foundations.

A crib dam of hewed timber which was built in Wisconsin a few years ago was 12 feet high, 20 feet wide and 400 feet long. The cribs were filled with stone and a roadway was built on top of the dam. The cost of construction was approximately $4000

for labor and materials, exclusive of the value of the timber used.

Where the stream bed is sandy and rather unstable a row of piling is sometimes driven across the dam site near the center of the sluiceway. These are cut off at the stream bed level and prevent the bottom from washing out. A dam of this character which was 10 feet high was constructed at the following cost:

Cutting and skidding 170 piles	$ 45
Driving 170 piles	210
Cutting and skidding crib timbers (5500 board feet)	15
Crib building	90
Dam gate construction	10
Building embankment and clearing up reservoir in rear	250
Total	$620

Four men were occupied twenty-one days in driving piles and ten days in building the structure. In addition one team and a driver were required for three days to skid the timber. Other workmen cut the piles and crib material. The embankment was made largely by hand labor and was not included in the thirty-one days.

Rafter or Self-loading Dam. — This type is cheaper to build than a crib dam and is used where a large head of water is not required.

Rafter dam foundations are constructed in the same manner as crib dams with pockets 8 by 8 feet in size. The mud-sills are drift-bolted to bedrock when possible. As the framework is built up, the face of the dam is drawn in from the level of the stream bed so that the upstream face has an angle of 3 horizontal to 1 vertical. The dam should be at least 8 feet wide on top. Two thicknesses of 3-inch plank or hewed poles are spiked on the sloping face, the joints being alternated and the whole covered with a bed of gravel. The rear mud-sill is protected by toe-spiling driven down to hard clay or bedrock, and the cribs are weighted down with stone. A dam of this character, 200 feet long and 10 feet high was built in the Adirondacks at a cost of $1600. A similar dam 60 feet long and 10 feet high was built in Canada for $700.

The frame for rafter dams is frequently supported on round or square timbers instead of cribwork.

Pile Dam. — The buttresses and wings of this type of dam are formed by a double row of piles driven to bedrock, the space

Photograph by H. R. McMillan.

Fig. 99. — The Sluiceway and Apron of a Rafter Dam on the Priest River. Idaho.

between them being filled with gravel and stone. The upstream face is banked up with brush and gravel to stop leakage. This type is not in frequent use, although it was at one time common in the Lake States.

SLUICE GATES

It is necessary to provide some form of gate for controlling the water in the sluiceway. The more common type is a lift gate the width of the sluice. It slides up and down in a groove formed by two heavy timbers nailed on each side of the sluice walls, which are far enough apart to allow the gate to work up and down easily. The gate may be lifted by levers, by a ratchet device or by a windlass operated by levers.

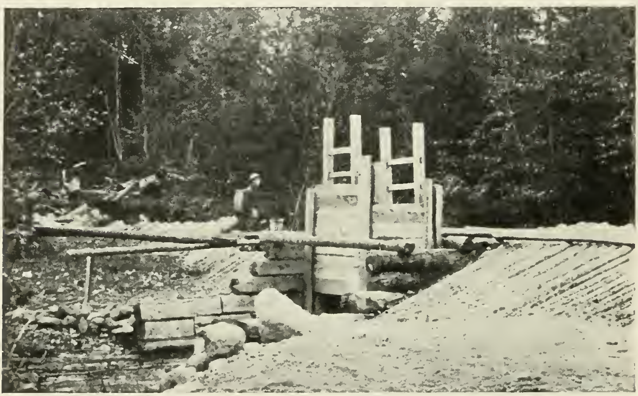

FIG. 100. — The Upstream Face of a Small Rafter Dam, showing a Common Form of Lift-Gate.

Bear-trap Gate. — This type of gate has been used frequently in Pennsylvania. The chief features are two rectangular leaves each of which has a length equal to the width of the sluice. They are fastened to the bottom of the sluice by hinges on which they turn. The upstream leaf overlaps the downstream one when the leaves are down and the gate open.

The gate is raised by the pressure of water from the upper pool, which is conveyed in a channel, controlled by a sluice gate, to a chamber (*A*), Fig. 101, constructed under the gate. A second channel, also provided with a gate or stopcock, con-

nects this chamber with the lower pool. When the connection with the upper pool is opened, while that with the lower pool is closed, water from the upper pool fills the chamber under the gate. This causes the downstream leaf to rise, first by flotation and then by the impulse from the flow of the water. The upper leaf is raised by the lower leaf which slides under it, the friction being reduced by rollers. The height to which the gate rises is limited either by stay chains, or by a wood cleat nailed on the under side of the upper leaf. In lowering the gates the operation is reversed, the connection with the upper pool being closed while that with the lower pool is opened. The gate may be made to assume any intermediate position by

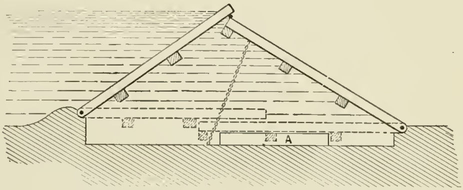

FIG 101. — The Bear-trap Sluice Gate.

regulating the extent to which the two valves controlling the inlet and outlet of the chamber under the gate are opened.

The objections to this form of gate are: (1) the overlap of the upper leaf over the lower one necessitates lifting a considerable amount of water when the gate is raised; (2) the head of water obtainable is only about one-third of the total width of the leaves; (3) the friction between the two leaves, even when reduced by rollers makes it difficult to operate the gate smoothly; (4) the gate must be made in one section and if the gate is wide one side is apt to go up faster than the other, causing twisting strains; (5) any driftwood or stones which may lodge between the leaves make the lowering of the gate impossible until the obstruction is removed.

Water can be let out of the reservoir very rapidly with a gate of this character, and the latter can be raised and lowered by

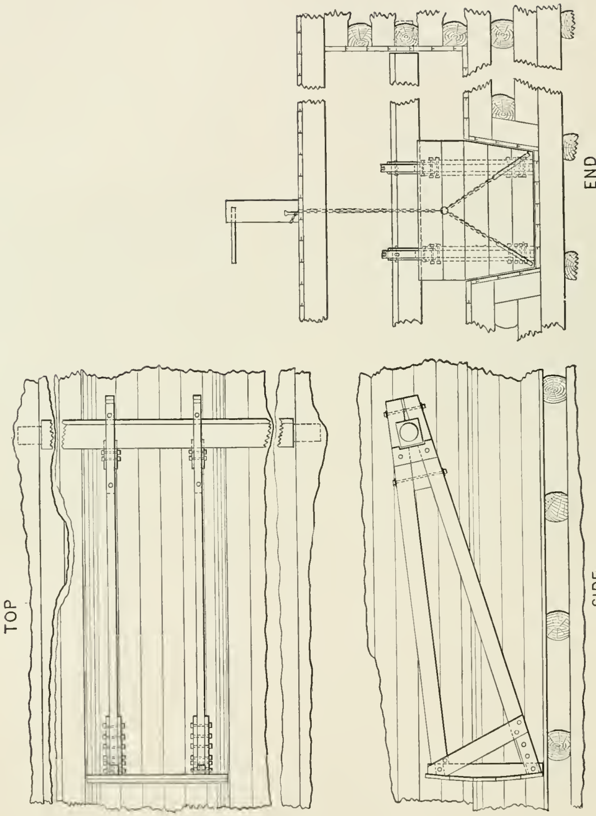

FIG. 102. — A Half-moon Gate used in a Low Sluiceway. Wisconsin.

one man as no special effort is required, both of which are advantages.

Logging dams with "bear-trap" gates 80 feet wide have been built and operated in Wisconsin.

Half-moon Gates. — A dam constructed to store water for log sluices often has a gate of a type called the "half-moon." It is not used for wide sluiceways nor for large heads of water. The gate, which is slightly curved, fits tightly into the sluiceway with the convex face upstream. It is supported by four arms from

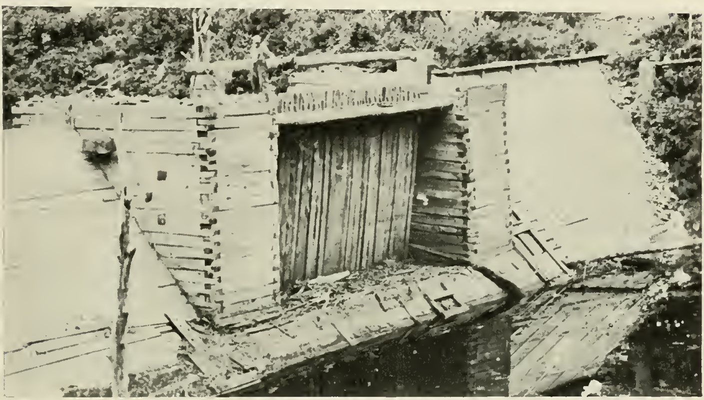

FIG. 103. — Upstream View of a Rafter Dam, showing a Needle Gate. Appalachians.

16 to 24 feet long, which extend to the lower end of the sluice where they are attached to a beam hung on bearings placed on either side of the top of the sluiceway. A platform erected over the gate supports a drum actuated by a hand wheel with gearing, or by a hand lever. Chains are attached to either side of the gate head and are passed up over the drum, and the gate, which swings through an arc of a circle with a radius equal to the length of the supporting braces, is raised by winding in the chain.

Needle or Bracket Gate. — Splash dams, especially in the Appalachian and Pennsylvania regions, are often provided with so-

called needle gates, which consist of hewed or sawed 3- by 5-inch or 3- by 6-inch scantlings placed vertically across the opening, thus forming a solid front. The needles are supported at the lower end by a cross-beam or groove cut in the base sill. The tops rest against a cross-beam to which the needles are often attached by short chains. The needles are raised either by a windlass, a crowbar or a lever. They are especially serviceable for dams at storage reservoirs through which logs are not sluiced, but where it is necessary to suddenly release large quantities of water in order to carry logs over very rough stretches. In the above case the needles may be liberated by breaking the bottom beam by a charge of dynamite.

Barn-door Gate. — This consists of one or two heavy gates or doors hung vertically on bearings attached to the sides of the sluice. Double gates are held in place, when closed, by an upright beam in the center of the sluiceway, and single gates by a similar beam placed on one side of the sluiceway. A horizontal pole is sometimes used instead of an upright one to hold the gate shut. These gates have been used in Pennsylvania and in some parts of the Appalachians, but they are not popular because the force of the water throws them open so violently that they are often damaged.

A light drop gate is often used to shut off the flow of water while the large gates are being closed.

LOG CARRIERS

Loggers operating near the headwaters of streams occasionally find it desirable to transfer logs from one water course to another in order to bring them down the stream on which the manufacturing plant is located.

A log carrier similar to the log haul-up in a sawmill is employed for elevating the logs to the maximum height desired, and a log sluice with a V-box 4 or 5 feet high and 7 or 8 feet across the top then carries the logs into the stream on the other watershed. Water for the sluiceway is furnished by a series of pumps of large capacity.

An interesting example of a device of this sort was the log carrier and sluice constructed some years ago in the Nipissing district, Ontario, Canada, to divert logs from the headwaters of the Muskoka River to those of the Trent River.

The logs were first transported up a log carrier 300 feet long to a reservoir 80 feet long, 7 feet wide and 8 feet deep, located 40 feet above the initial level. A 450-horse-power engine furnished power for the jack works at the reservoir, and also for a set of centrifugal pumps with a capacity of 20,000 gallons per minute, which provided water for the reservoir, and for a log sluice which was 3000 feet long and had a 4.5 per cent grade. The logs as they reached the foot of the sluice were transported by a log carrier up a 100-foot rise to a lake $\frac{5}{8}$-mile distant, where they were placed in a boom and towed to the head of the river down which they were driven. The second carrier consisted of eight sections, each with a massive jack works driven by rope transmission from a 400-horse-power horizontal water wheel located near the center of the haul-up. Water for power purposes was brought in a flume from the terminus of the carrier. The conveyor chains were made with 1-inch round links and had log seats at intervals of 8 feet. The capacity of the carrier was 10,000 logs in twenty-two hours.

IMPROVEMENT OF THE STREAM BED AND BANKS

Before a stream can be driven it must be cleared of fallen timber, snags and boulders. The former is often cut into short lengths with an ax and allowed to drift downstream, or is hauled out on the banks. Snags, rocks and similar obstructions are removed with dynamite. This work is done in the summer and early fall when the water is low.

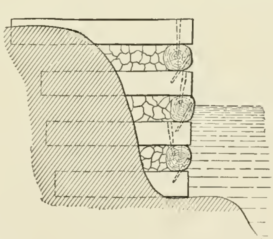

Fig. 104. — An Abutment for the Protection of Stream Banks.

Pier Dams and Abutments.— Pier dams are cribwork structures used to narrow the channel of a stream, guide logs past rocks

and other obstructions, and in some cases to block an old channel and divert the water into another course.

They are built in a manner similar to the piers of crib-dams with cribs from 6 to 8 feet square, and mud-sills fastened to bedrock or firmly anchored in the stream bed. The cribs are loaded with rock to give them stability.

Abutments are used to protect the banks of streams during flood time, and prevent them from being worn away. The usual form consists of a cribwork of timber built into the bank. The space between the shore and the timbers is filled with rock to prevent the bank earth from washing out. Where streams pass through wide bottoms and the banks are too low to confine the flood water, an artificial channel is sometimes created by constructing false banks of lumber. Cribwork supports a strong frame of timbers on which heavy planking is nailed.

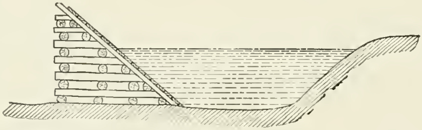

FIG. 105. — An Artificial Channel used to confine Flood Water in a Narrow Bed.

Booms. — Backwaters, pockets, low banks, obstructions and shallow places where logs are apt to be lost or stranded occur on most streams. Booms, consisting of long sticks of timber fastened together end for end and moored to objects on shore or to piling or cribs in the stream, are used to confine the logs to the channel. Booms are also used to aid drivers in sluicing logs through dams, for confining logs at sorting gaps and storage points, and for towing. They are built in many forms and are called sheer booms when used to confine logs for storage purposes in given channels and towing booms when used to impound logs for towing purposes. They are again designated as limber and stiff booms according to their manner of construction. Both sheer booms and towing booms are often of the same pattern and are known as the "plug" boom, "sheep-shank" boom, "chain"

boom, "bracket" boom, "fin" boom and "barge" boom. The first three are single-log limber booms, the names referring to the manner of attachment one to the other; the bracket boom is a stiff boom several logs wide, and the fin and barge booms are either stiff or limber.

Plug booms, also known as "plug and knock down" booms, consist of logs fastened end to end with short pieces of rope or withes whose ends are passed through holes bored in the ends of the boom and securely fastened by plugs driven after them.

Booms of this character are serviceable as a makeshift when stronger fastenings are not available.

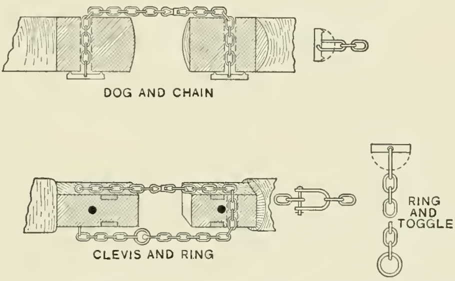

FIG. 106. — The Methods of fastening Boom Sticks with Chains.

Sheep-shank booms are temporary booms fastened together by rope, a half hitch being made around the ends of the logs. They are used for repairing breaks in other booms where rope is the only equipment available.

Chain booms are the common form of limber boom in use to-day. Short chains are used to connect the logs, and are fastened in several different ways: (1) by a chain and dogs; (2) by a ring and toggle; (3) by a clevis, making an endless chain. The latter form is used very commonly for towing purposes and for storage areas because the booms can be readily uncoupled.

The bracket boom is a stiff boom made three or four logs wide. The logs are fastened together by short boards nailed cross-

wise of the boom, or by short poles fastened to the logs by means of wooden plugs, chains or withes. Booms of this character are stronger than single booms and are used on the upstream side of splash dams for converging logs toward the sluiceway, and are also used around storage areas and sorting gaps as runways for men.

The fin boom is often employed to change the course of logs from one side of a stream to the other, or to guide them past obstructions. It is especially serviceable on a navigable stream

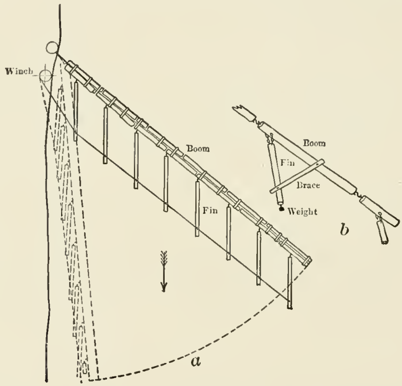

Fig. 107. — A Fin Boom. *a*. A movable fin boom both open and closed. *b*. The arrangement of boom and fins for a permanent fin boom.

where permanent booms cannot be maintained, and in places where it is not feasible to moor the outer end of the boom to a crib or pile. The shore end must always be upstream. The fin boom may be either limber or stiff, preferably the latter, and may be permanent or temporary. It consists of a main boom to which the ends of pole or plank fins are attached by chains at regular intervals. When the boom must be opened and closed at frequent intervals the outer ends of the fins, which act as rudders, are connected by a rope or cable which passes around a drum or power-winch located on shore, while on stationary booms the fins are weighted at the ends to give them rigidity,

and are fixed in a permanent position by means of a brace extending from the fin to the main boom.

The boom may be thrown across a stream at any angle less than 90 degrees by winding in on the cable and increasing the angle between the boom and rudders. The boom may be brought to shore by letting out cable.

A barge boom consists of a limber boom, three or four logs wide, the upper end of which is fastened to a barge anchored in midstream and the downstream end to a tree on shore. A boom of this character is serviceable in a navigable stream where permanent booms cannot be used, and where the stream bed cannot be obstructed with piling or cribs. It is often used in connection with a fin boom when it is desired to shunt logs to one side of a wide stream.

STORAGE AND SORTING FACILITIES

On all large streams on which logs are transported, the properties of various companies become intermingled, and at destina-

Fig. 108. — Piers built in a River to hold Storage Booms in Place. Minnesota.

tion it is necessary to sort out the timber of each owner. For this purpose sorting works are maintained at points where any given logs are to be manufactured, and extensive log storage

facilities also are often provided. Both the sorting and storage works are generally owned by corporations (p. 368).

The storage booms consist of large pockets, extending sometimes for miles along one or both sides of the stream, into which logs are shunted until the sorters are ready for them, and also to hold sorted logs until wanted. The outer boundary of these pockets is formed by single booms consisting of logs from 2 to 3 feet in diameter fastened together with 1-inch or $1\frac{1}{4}$-inch chains or other devices. The boom sticks are held in place in midstream by cribs or nests of piling placed 75 or 100 feet apart.

Photograph by R. B. Miller.

FIG. 109. — Log Storing and Assorting Works on the St. John River. New Brunswick.

Cribs are built of round logs from 16 to 24 inches in diameter and of various sizes depending on the character of stream in which they are placed and the amount of strain they must withstand. The foundation is laid on bedrock or solid bottom and the frame built up in the form of a square or rectangular crib. In some cases the cribs are built rectangular in form above the water, but usually the upstream face is drawn in at an angle of from 30 to 40 degrees and planked over. The sloping face prevents ice and driftwood from forming a jam behind the crib and causing it to be carried away.

The cribs are filled with rock to anchor them firmly. A common method of attaching the boom sticks to the cribs is to drive a pile in the center of the crib. After a large iron ring has been loosely fitted over this pile the boom is fastened by a chain to the ring, and as the water rises and falls the ring is slipped up and down with the chain. Where piling is used instead of cribs a nest of three or four are driven together and bound with chains or cable.

Storage booms are usually taken in and the chains repaired after the drive is over. They are replaced early in the spring, as soon as the ice leaves the stream.

The capacity of storage booms varies with the size and length of timber handled. The following table[1] shows the area in acres required to store spruce logs of several sizes and lengths, and also the number of boom logs required to impound given quantities of timber when the logs are forced into a compact body by the current of the stream, all sticks floating on the surface.

Average length.	Average diameter.	Average scale per piece.[2]	Area for storage of 1,000,000 feet.
Feet.	Inches.	Board feet.	Acres.
15.3	5.9	21.4	13.41
20.5	6.7	31.8	11.94
24.6	10.4	90.7	8.15
30.0	15.6	249.48	5.34

[2] Blodgett rule.

The average storage capacity of medium-sized white pine and yellow pine logs is approximately 250,000 feet per acre.

Sorting Equipment. — The main feature is the sorting jack where logs are separated and deflected into the storage pockets downstream. The usual type of sorting gap consists of two opposite rafts or bracket booms placed from 30 to 50 feet apart and connected by an elevated runway on which the sorters stand and separate the logs by marks as they pass under them. There are many forms of gaps governed by the amount of work

[1] Boom Areas, by A. M. Carter, Forestry Quarterly, Vol. X, No. 1, p. 15.

to be done and the physical conditions that must be met. Fig. 110 shows a sorting gap on the St. John River near Fredericton, New Brunswick. This consists of two block piers 50 feet apart, behind which are rafts built of five logs each, so arranged that five gaps, each 22 feet wide, are formed on each side. The space between opposite rafts is spanned by 4-foot plank bridges on which the sorters stand. The division boom shown extends downstream for 2000 feet to sheer booms which deflect the logs to the American and Canadian sides. Seventy-five men are employed at this gap and during the season 150,000,000 feet of logs are handled.

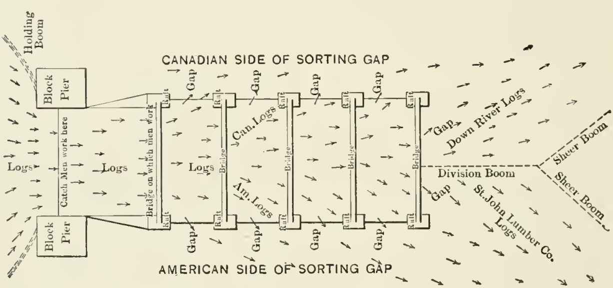

FIG. 110.—A Sorting Gap on the St. John River near Fredericton. New Brunswick.

A sorting device used in the Appalachian region is shown in Fig. 111, *a*.

This consists of a sheer boom (*A*) moored to a tree on the bank and braced by a secondary boom at (*B*). The boom (*A*) is held in place in the stream by cables attached as shown in Fig. 111, *b*. The lower end of the boom is broken at (*C*) and may be opened to allow logs and driftwood to pass downstream. A sorting platform (*D*), with braces (*E*) and (*F*), is provided on which the workers stand and shunt the logs to be stored into the pocket (*G*). The remainder pass downstream to other storage pockets or to points below. The boom (*H*) is elevated by means of a built-up raft (Fig. 111, *c*) to allow logs to pass underneath into the storage pocket.

Rafting Works. — These may be located below sorting gaps, at the head of still water on non-navigable streams or at the terminus of a logging railroad, or other form of transport along the shore of a lake or at tidewater. The form of the rafting works is governed by the character of the stream or body of water and by the form of raft constructed. On rivers where rafts are limited in width because of the size of the channel, rafts are made long and narrow and the rafting works, if logs of numerous owners are handled, may consist of many pockets

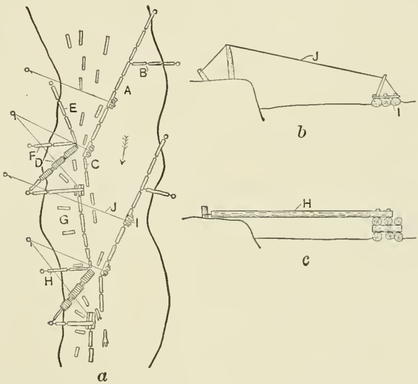

FIG. 111. — A Patent Sorting Device used in the Appalachian Region.

whose boundaries are marked by bracket booms with plank runways which are held in position by piling.

On the Great Lakes, where logs are towed loose in booms, storage areas off-shore are provided in which logs are held until a sufficient number have accumulated. These areas are bounded by heavy sheer booms held in place by piling. The rafts are made up by surrounding a group of logs with heavy towing booms and towing them out of the storage areas.

Along some of the tidewaters of the Atlantic seaboard logs are made into bundles and towed to the mills. The rafting works here consist of an unloading wharf which projects into

the stream, and special devices for holding chains and cables while the logs are being bundled (p. 387).

On the tidewater of Puget Sound, where large numbers of logs are rafted to the mills, a rafting works consists of an unloading dock several hundred feet long projecting into the storage area. The latter is enclosed by sheer booms which are held in place by piles driven about 70 feet apart. A rafting pocket 75 feet wide and 800 feet long is enclosed in booms and in this the rafts are built in sections.

Ocean-going rafts are built on tidewater along the Columbia river. The usual storage area is provided and in addition, cradles in which the rafts are built (p. 390).

THE DRIVE

The season in which logs are transported by water varies in different regions. In the Northeast and the Lake States loggers depend primarily on the spring flood waters that are caused by the melting snow and hence the drive must begin as soon as the ice goes out of the streams, since the water supply gradually decreases as the season advances, and on the smaller streams may be insufficient by early summer.

In the Appalachians and in the South where the snowfall is limited, reliance is placed on freshets or heavy rainfalls for water to float the logs and the drive is conducted whenever water is available. On large bodies of water like the Great Lakes, Puget Sound, and the Ocean the governing factor is the storm period and the summer months are preferred because there are a minimum number of storms during this season.

Conduct of Drives. — The business conduct of drives on streams may be under the control of one man, a group of individuals, or a corporation, depending on the ownership of the timber. Rafting on the large rivers, with the exception of the Mississippi, on lakes and on the ocean is usually undertaken by individuals or corporations.

Drives on large rivers often originate on numerous small streams around the headwaters, from each one of which come the logs of an individual or a company. Under these circumstances

the stream improvements are made and the drive is conducted by one firm. On reaching the larger stream the logs of all parties become intermingled and the drive is then conducted as a "union" drive or as a corporation drive.

On union drives which have been frequent in the Northeast, the expense of improvements and labor hire is apportioned among the companies and individuals according to the amount of timber each has in the stream. The direct control of the drive is vested usually in the interested members, in rotation, and each one has an employee at the sorting gap to look after his interests when the logs are assorted.

A more common method is the control of the main drive by boom companies chartered by the State in which the business is conducted. The stream, if long, may be divided into several sections, each in charge of a separate corporation. The membership of such corporations is usually confined to loggers who use the river for log transportation; however, it often does not include some of the smaller operators. Many of the boom companies operating in the Lake States, especially on the Mississippi River and its tributaries, have a limited capital stock divided among a few shareholders.

Another form of membership is represented by companies, such as the St. John River Log Driving Company, operating in the vicinity of Fredericton, New Brunswick.[1] Each logger having 100,000 feet or more passing through the limits of the company is eligible to membership, on filing with the Secretary a statement of all logs placed in the stream and their point of origin, a list of all log marks used, and certain other required facts. On filing this report the applicant becomes a member and is entitled to one vote for each 100,000 feet of logs he has in the drive. Thus every logger of any consequence has a voice in the administration of the drive.

All states having large streams which are used for the transport of logs have laws relating to the rights and privileges of loggers and setting forth the duties and liabilities of incorporated boom

[1] St. John River Log Driving Operations, by G. Scott Grimmer, Canada Lumberman and Woodworker, Vol. XXXII, No. 11, June, 1912, p. 28.

companies. The charters of boom companies usually regulate the prices to be charged for handling and rafting logs. The state laws of Minnesota provide for inspection and scale of logs in the booms by a surveyor-general and his deputies, for which a fee of 5 cents per thousand feet for all logs scaled is charged against the boom company. The surveyor-general is empowered to seize and sell logs in case of non-payment of the fee.

On some tributaries of the Ohio River, especially on the Big Sandy down which great quantities of logs have been floated, the practice is for individuals to drive their logs loose from the headwaters of the small streams to private rafting works located on the lower course of the Big Sandy where the logs are made into rafts by contract, floated to the mouth of the river and there taken in charge by the owner and towed down the Ohio River to the mills.

On the Pacific Coast the logs are brought to tidewater by logging railroads and made into rafts at the owner's rafting works.

A. LOG MARKS AND BRANDS

Some method of identifying the logs of different owners when they are assorted at destination is imperative and lumbermen have adopted the system of branding their logs at the skidways, in the forest or at the landing on the stream. The brands consist of numerals or characters, mounted on the head of a sledge hammer. A log is stamped at several places on each end so that no matter what portion of the log is afloat the brand can be readily seen.

To further aid in the identification of logs the use of a bark mark which is a design cut on the log near the end is obligatory in some states. This may be made either by the sawyers when they cut up the tree or at the landing. A bark mark is often used in connection with a "catch mark" painted on the ends of the log. In such cases a brand is not used. The number of brands and marks used on a given stream is sometimes large, each logger often employing several to distinguish logs coming from given streams or sections of land. Some loggers use a new set each season in order to keep the logs of different years sepa-

rate. On the upper Mississippi River more than 2000 log marks have been registered with the surveyor-general, and over 1600 have been employed during a single season.

The marks and brands represent a great variety of figures comprising single letters, monograms of two or three letters and numerous figures which are known amongst river drivers by fantastic names.

Log brands have always been the distinguishing feature for logs in the Adirondack region, while in Maine bark marks are extensively employed. Both forms are used on the Mississippi

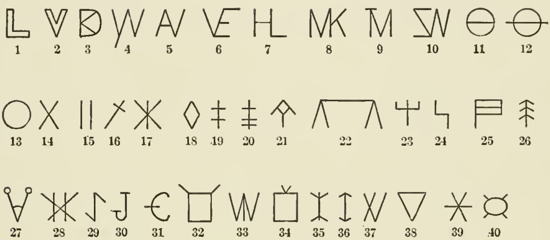

Fig. 112. — Some Mississippi River Log Marks. 1–10, monograms; 11, blaze notch; 12, notch girdle; 13, scalp; 14, cross; 15, notch; 16, dagger; 17, cross girdle; 18, diamond; 19, twenty; 20, thirty; 21, umbrella; 22, saw horse; 23, fork; 24, straight S; 25, flag; 26, pine tree; 27, inverted A with scalps; 28, fifty; 29, pot hook; 30, fish hook; 31, bar C; 32, box with ears; 33, wild goose: 34, sheep head; 35, crow foot; 36, double dagger; 37, fifteen; 38, triangle; 39, star girdle; 40, turtle.

River and its tributaries, and also in many parts of the Appalachian region. Brands are in extensive use on the Pacific Coast where logs are transported by water, but are seldom used in the interior.

When registered[1] with some designated state or county official

[1] "Failure of owner to comply with Compiled Laws, section 5083, providing for the recording of log marks, was only effective to deprive the owner of the statutory presumption of ownership of logs unmarked with the recorded mark, and did not deprive him of his property in logs, the title to which he might establish by other means, including an unrecorded mark used by him." Whitman *vs.* Muskegon Log Lifting and Operating Co. Supreme Court of Michigan, 116 Northwestern 614.

(the surveyor-general in Minnesota, in most other states the County Clerk of the county in which the head office is located) brands constitute trademarks of the individuals registering them, and their rights to the timber so marked are fully protected by law.

The obliteration or removal of brands or bark marks ("de-horning") is regarded as a felony in most states. The highest courts of some states[1] hold where logs are presumptively marked according to law and are floated down a stream, that if the owners annually endeavor to recover those that sink and become imbedded in the stream, such logs cannot be regarded as lost or abandoned property whether the marks are distinguishable or not.

Loggers, therefore, do not lose their property rights in lost logs if originally they were properly marked by the owner, and he used due diligence each year to recover them. On the other hand, according to the Supreme Court of Minnesota,[2] logs in water are abandoned when not in the possession of or under the control of any person, and which have no distinctive mark or marks on them that have been recorded with the proper officials. Such logs are the property of the person who collects them and causes them to be marked. These logs are known as "prize" logs and on union drives they are divided in rotation, as they pass the sorting gap, among the loggers having timber in the stream. Where the drive is conducted by a boom company all prize logs caught in the booms are held as the property of the company and sold at auction to the highest bidder.

B. SPECIES THAT WILL FLOAT

Although the majority of species indigenous to the United States will float to some extent, yet many of them cannot be transported successfully by water. The coniferous woods are

[1] See Whitman *vs*. Muskegon Log Lifting and Operating Co. Supreme Court of Michigan, 116 Northwestern 614.

[2] See Astell *vs*. McCuish. Supreme Court of Michigan, 124 Northwestern Reporter 458.

the most satisfactory floaters, but among them there are several species such as yellow pine, green hemlock, and the butts of larch, redwood and some other species that can be handled only with indifferent success. The buoyancy of hemlock is increased by peeling the timber and allowing it to season for a short period before placing it in the water.

Hardwood logs, such as basswood, poplar and cucumber, float well and can be driven to advantage, although basswood is apt to become discolored, which greatly depreciates it in value. Oak, beech, maple, birch and other heavy hardwoods can only be floated with difficulty unless they are especially prepared or are rafted with lighter species. Some loggers cut and peel oak in July, August, September and October, place it on skids near the bank and allow it to dry out for from sixty to ninety days. It then becomes light enough to float for short periods.

Another method[1] is to peel and season the logs, then paint the ends with two or three coats of paint and raft with lighter species. Holes also may be bored into logs and plugged up so as to form air spaces and increase the buoyancy of the timber.

White birch for spool stock is sometimes driven for short distances in Maine. The green timber will float for a short period, although it is seldom put into the water in this condition. An effective method is to fell the trees during the summer months and leave the tops on the trees until a large amount of moisture has been removed. Again the trees may be felled, the tops cut off and the timber left in the forest to season for from eight to twelve months. This method is less satisfactory than the former because the sap of the logs stains badly during summer months, if left for long periods.

The following lists show the relative floating ability of several species.

[1] There is a serious objection to this method of handling hardwoods because their value is usually reduced by checks and incipient rot. Hardwood cut during the spring or summer must be converted into lumber in a few weeks if the best results are to be secured.

Good floating ability.	Average floating ability.	Poor floating ability.
Spruce	Yellow pine	Oak
White pine	Sweet gum	Hickory
Hemlock (dry)	Sycamore	Birch
Basswood	Douglas fir	Beech
Poplar	Chestnut	Elm
White cedar		Ash
Redwood (except butts)		Cherry
Balsam		Redwood (butts)
Larch (except butts)		Larch (butts)
Cypress		
Cucumber		

C. LABOR

Labor employed on log drives is chiefly recruited from the logging camps which have ceased operations by the time the streams are in condition to float timber. Although the work is hard, the hours are long and the men are often exposed to many hardships in the pursuit of their work, there is a certain glamour and fascination about it which attracts forest workers and in normal times loggers seldom have difficulty in securing a sufficient number of men.

The labor in the Northeastern part of the United States is largely composed of French Canadians who make admirable river drivers.

Log driving on small streams is done largely from the banks, except where log jams occur, while on large streams the work must often be done from boats called bateaux [1] or from the logs themselves. The river drivers are often subject to great personal danger in freeing lodged logs and in breaking up jams which form at narrow points in the stream, or in places where the channel is obstructed by rocks. A "key log" around which a jam is formed must be freed before the mass can be started, and this may be done either with tools or by a charge of dynamite. Only the most skillful men are allowed to perform this work, because great presence of mind is required on the part of

[1] These are strongly built boats with a sharp prow and are fitted with two pairs of oars and guided by a single oar used as a rudder. They have a capacity of from six to ten men.

the driver when the logs start to move. Log drivers, especially on rough water, are among the highest paid men in the woods.[1] On small streams log drivers are housed in log camps or in tents, while on river drives the men frequently live in a house boat or a tent called a "wanigan," which is mounted on a scow or raft and floated down the stream as the work proceeds. Tents on shore are also frequently used where facilities can be provided for moving them in wagons or in boats.

D. CONDUCT OF THE DRIVE

The Drive on Small Streams. — Drives usually start on the upper courses of some small stream where the logs have been "banked" in the stream bed, and parallel with it, or else scattered over the surface of some lake or pond near its mouth. The "banking ground" is often above a splash dam which furnishes sufficient water to carry the logs down to the rear of another dam or to the main stream on which they are floated to the mill.

As soon as the ice has gone out sufficiently to clear the stream, booms are placed in essential spots along the channel and the dams and other equipment placed in good repair after the winter season. A head of water is accumulated on the banking ground and a crew is set to work to "break down" the "landing" or "bank."[2] This consists in setting the logs afloat in the current so they can proceed downstream. The sluice gates of the dams are opened a short while before the logs are started through and should not be closed until several minutes after the logs have ceased coming, otherwise jams will form at points along the channel. The work starts on the pile farthest downstream and in the center of the channel, the logs from the top of the pile being thrown into the water by means of peavies and

[1] Log drivers in Maine receive from $2.25 to $3 per day and board, which includes four meals per day. Drivers on the large streams in the West receive 50 cents per hour, exclusive of board, which costs approximately $5 per week.

[2] In the Appalachian region, logs frequently are not banked but are scattered in the beds of the streams where they await a freshet to carry them down the stream. In such cases a crew to break landing is not required. Dependence is placed on the current to start the logs.

timber grapples. This continues until the drivers have cleaned a channel wide enough to enable them to roll the remaining logs from the pile into the stream. After having cleaned up one section they proceed to loosen the next section above, and are sometimes obliged to explode a small charge of dynamite to free the logs which are frozen together. The loose logs float down to the splash dam where they are converged toward the sluiceway by bracket booms. Drivers stationed on the latter

Fig. 113.—A Log Driving Crew at the Landing waiting for a Head of Water. New Hampshire.

keep the logs parallel to the current and prevent them from jamming when they pass through the sluice. Workmen armed with peavies and pike poles[1] are stationed at strategic points along the stream to prevent logs from becoming stranded on sand bars, and from forming jams on rocks and in narrow places in the channel.

[1] This has an ash or hickory handle, from 12 to 20 feet long, on one end of which is attached a screw pike and hook. It is very serviceable in controlling logs in water. The screw pike when forced into a log has a tenacious grip which enables the workman to exert a strong pull without losing his hold on the log.

Jams and stranded logs can often be moved by the use of a dog-warp which consists of two strong hooks attached near the center of a rope stretched across the stream. A crew of three or four men is stationed on either bank and by catching one or the other of the hooks into logs the men are able to pull them in either direction. The use of dynamite is resorted to when other means fail.

The drive on small streams continues until all of the logs have left the banking ground. A crew then starts to "pick rear," which consists in collecting all the stranded logs along the stream and in the sloughs and putting them into the water so that they will go out with the drive. This work is generally done by men who use timber grapples and peavies for carrying and dragging the logs. Horses are employed when available and the conditions are suitable for their use.

When the course of the drive is across a lake it is necessary to confine the logs in booms and tow them to the outlet.

A limber boom called a "trap" or "catch" boom is placed at the head of the lake around the mouth of the stream and the logs are confined in it until a sufficient number are secured, when the shore ends of the boom are closed and the raft is towed across the lake. The mouth of the stream is either closed temporarily or a second boom is placed in position at once. Where the distance is short and the amount of timber to be moved is limited, it is "kedged" or "warped" by "headworks" of the type shown in Fig. 114. This consists of a rough capstan, holding from 300 to 400 feet of rope, which is mounted on a raft, and the latter attached at the forward part of the boom. A heavy anchor fastened to the free end of the rope is carried forward in a boat and dropped in the path of the raft. The capstan is then revolved either by man or horse power. When the raft reaches the anchor, the latter is lifted and again carried forward. A headworks of this character cannot be used to advantage against a head wind.

Large quantities of logs are usually handled by a "steam-warping tug" or "alligator," which consists of a flat-bottomed, steel-shod scow on which is mounted a pair of twenty-horse-

power engines and a large capstan or windlass. The boats are propelled either by twin screws or side wheels and are so constructed that they may be drawn overland on skids under their own power. When towing, a cable is fastened to some convenient tree on shore or an anchor is thrown out several hundred feet in advance of the raft and the tug then run back and attached to the raft which is advanced by winding up the cable on the capstan. Under a favorable wind a tug of this character will handle 60,000 board feet and under a head wind, 30,000 feet.

Photograph by D. N. Rogers.

FIG. 114. — A "Headworks" used to tow Log Rafts across Small Lakes. Maine.

The cost of drives on small streams ranges from 25 to 30 cents per thousand feet for a few miles up to $1.25 for a distance of from 30 to 50 miles. As a rule transport on small streams is more expensive per thousand feet per mile than on large ones, because of the limited amount of timber handled, the rough character of the channel, and the greater number of improvements per mile that are required.

Individual drives on small streams are in charge of a foreman who often is the woods superintendent, or the boss of the logging camp at which the timber was cut. One or more subforemen aid him.

The Drive on Large Streams.[1] — The driving problems on portions of the route are often similar to those on small streams, but in general the difficulties incident to the transport of logs are not so great.

The channel is wider, with longer stretches of smooth water, and the greater volume of timber annually passing downstream makes it practicable to improve the channel to a far greater degree than is feasible with small streams. Fewer men in proportion to the amount of timber handled and the distance covered are required, and under normal circumstances the expense per thousand feet for labor is less. A large portion of the driving work on the average stream consists in the prevention of jams at curves, on sand bars, at rocky narrows and similar places, and "picking rear" after the main drive has passed. On many large streams the banks for a portion of the distance may be low, so that logs can float out of the channel into sloughs or over land inundated during flood time, and the drivers must keep their booms in good condition to prevent this and to keep the logs moving.

Crews are divided into squads, under subforemen, and are stationed at danger points along the stream. These crews must do much of their work from bateaux or by standing on logs, because of the width of the banks. In place of "alligators" and "headworks" powerful side wheel, end wheel or screw tugs are employed for the transport of large quantities of logs across lakes, or down streams where it is necessary to confine the logs in booms.

When the head of the drive reaches the first sorting gap, a crew of men begins sorting and this continues during the summer and fall until the logs are all assorted, the water fails or ice closes the river. If no ill luck has attended the drive the last logs are usually down by October first.

The drive on the upper Connecticut River originating on the Wild Ammonoosuc in New Hampshire and extending to Bellows Falls (17 miles on the Ammonoosuc and 93 miles on the Connecticut River) begins about the first of April and lasts from twenty-

[1] See page 363.

three days to six months. The average time is about six weeks. One hundred men are required on the Ammonoosuc and about sixty on the Connecticut River. The cost per thousand feet delivered at Bellows Falls for the 1909 drive, which was conducted under favorable conditions, was $1.18 per thousand feet. In 1908 the cost was $1.71 and in 1907, $1.40, while in some years it has been nearly $2 per thousand feet. The high cost is due to the rough character of the Ammonoosuc channel which, though fairly straight, contains many rocks. The annual cost of improving the Ammonoosuc has been from $500 to $700.

On the Penobscot River in Maine, the average length of drive is approximately 150 miles and the longest drive which originates on either the North or South Branch of the West Branch is about 240 miles. The average quantity of material annually driven down the West Branch is 130,000,000 feet, about three-quarters of which goes to Millinocket, and the remainder to Bangor and vicinity. The drive begins about April 20th and the last logs reach the booms above Bangor about October first. Approximately 2500 men are employed for the first six weeks and after the logs reach the main stream the force is cut to about 200 men, exclusive of those occupied at the sorting gaps.

The cost per thousand feet for driving logs on various portions of the Penobscot River has been as follows:[1]

Year.	Locality.	Distance.	Cost per 1000 feet.
		Miles.	
1903–1912	Head of Chesuncook lake to Shad pond..	60	$0.70
1898–1907	Grand lake dam to Penobscot boom....	89	.90
1898–1907	Haskell boom to Penobscot boom.......	84	.82
1898–1907	Sebois river to Lincoln.................	47	.66
1898–1907	Sebois river to Penobscot boom.........	72	.56
1898–1907	Soldier brook to Penobscot boom.......	62	.62
1898–1907	Medway to Penobscot boom............	51	.80
1898–1902	Head of Chesuncook lake to Penobscot boom	120	1.17
1898–1902	Shad pond to Penobscot boom..........	59	.40

[1] "Water Resources of the Penobscot River Basin, Maine," U. S. Geological Survey. Water Supply Paper, 279, Washington, 1912, p. 211.

The cost of handling logs by the St. John River Log Driving Company in New Brunswick for a distance of 214 miles has been as follows:

1906	$1.80 per 1000 feet
1907	1.90 per 1000 feet
1908	2.00 per 1000 feet
1909	2.07 per 1000 feet

The cost of the drive itself, exclusive of the sorting and rafting charges, has been 26 cents per thousand feet.

The Restigouche Log Driving and Boom Company, which operates on 65 miles of the Restigouche river in New Brunswick, handles approximately 100,000,000 feet per year. The charges for 1912 were as follows: driving to the boom limits, 18 cents per thousand; rafting charges for merchantable pine and spruce, 55 cents per thousand; undersized pine and spruce, 65 cents per thousand; cedar, 60 cents per thousand. The rafts are towed to the mills by the log owners at their own expense.

RAFTING ON STREAMS

Rafting is a common method of handling logs on large streams and lakes and is practiced in all parts of the United States. The motive power is usually end-wheel or side-wheel steamers on small bodies of water, and screw-propelled tugs on large bodies of water. Rafts are now seldom drifted with the current. The advantages of rafting are:

(1) It prevents loose logs from scattering and becoming entangled in bushes along the banks, and from being stranded on flats submerged at high water.

(2) It enables the water transport of nonportable species which can be buoyed up by fastening them to logs that can float.

(3) Extensive booms are not required at destination to catch the logs as they come down.

(4) It insures prompt delivery on lakes and other waters where there is no current to carry the logs along.

(5) The Federal Rivers and Harbors Act of March 3, 1899, declares "that it shall be unlawful to float loose timber or logs

in streams actually navigated by steamboats in such manner as to obstruct, impede, or endanger navigation."

There are a variety of forms in which rafts are built, depending on the character of the water on which they are to be towed, the kind of timber rafted and on the Federal regulations[1] governing rafting.

Bag or Sack Booms. — These are used on the Great Lakes and on large, smooth rivers. They consist of a single or double row of boom sticks surrounding the impounded logs. For lake work

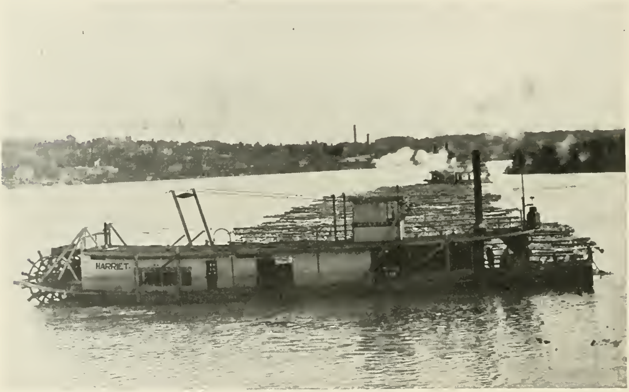

FIG. 115. — A Mississippi River Log Raft, showing the Method of Control by End-wheel Steamers.

short boom sticks of large size are preferable because loose logs are less apt to slip under them than they are under the long ones. On the Great Lakes double booms with connecting chains made of $1\frac{1}{4}$-inch iron are considered superior to single booms. During the period when the exportation of logs was permitted by the Provincial Governments of Canada, immense quantities of white pine were rafted to this country and manufactured at points along the Great Lakes. The season for towing was from June 1

[1] The Federal government specifies the form, size and character of rafts that may traverse certain navigable waters and harbors.

to October 15. The rafts contained from 2,000,000 to 6,000,000 feet each, and were handled by powerful tugs. The transport of logs from Canada to the United States ceased in 1898 when an embargo was placed on the export of logs from Crown Lands.

Rafts Fastened with Poles. — The common form of raft on the Ohio River and on some southern streams is one in which the logs are made up into raft sections. The logs in each section are attached to each other by poles placed across the logs and fastened to them by means of rafting dogs. The sections are fastened together by cables.

On the Ohio River poplar and other logs are rafted in lengths of from 20 to 60 feet. The longer logs are preferred because

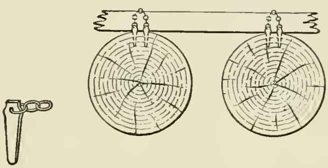

FIG. 116. — Method of fastening Poles to the Logs by means of Iron Dogs.

of the greater ease in rafting and also because the laws of adjoining states allow a fee of 25 cents per stick without regard to length, to all parties who catch and hold logs for rafting. On the upper reaches of the Big Sandy River floating logs are caught and about sixty sticks are made into a raft which is from eight to twelve logs wide and from 250 to 400 feet long. The logs are bound together with small poles 20 feet long which are placed at intervals of from 10 to 12 feet. Rafts are equipped with long sweeps at each end to assist in guiding them, and each one is floated down to the mouth of the stream in charge of two men. The owner makes from twelve to sixteen rafts, containing from 700 to 900 sticks, into a fleet and takes it downstream to the mills under the control of a tug. An occasional fleet containing from 1900 to 2000 logs is handled which is regarded as the maximum size practicable.

A modification of this form of raft is occasionally used for handling yellow pine in the South. The rafts consist of sections one log long held together by poles which are attached to

Photograph by R. B. Miller.

FIG. 117. — Loading the "Bottom" of a Raft with Logs, by means of a Parbuckle. A bracket boom is shown on the left. New Brunswick.

the logs by a wooden plug driven into holes bored through the poles and into the timbers. Several sections are then made into a raft and floated downstream to the mill under the guidance of raftmen who steer with long sweeps or oars.

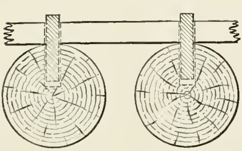

FIG. 118. — Method of Attaching Rafting Poles to the Logs, by means of Wooden Pins.

On some of the streams in the Northeast assorted logs are made into rafts and towed to the mills. The St. John River Log Driving Company of Fredericton, New Brunswick, makes up its rafts in the following way. The logs after being assorted are run into pockets according to ownership. About thirty logs are fastened together at one end with a "rattling line" which consists of a cable on which are strung the

necessary number of ring dogs. This "joint," as it is called, is then floated out of the pocket and down the "rattling run" to the "bottom makers" who place two boom poles across the raft, and bore holes through the boom poles and logs which are then fastened together with hardwood pins. The rattling lines are then removed and the bottom passes down to a loading machine where a top load of logs is placed on the "bottom." The joints are then scaled and floated downstream where from five to seven of them are fastened together by short pieces of poles, called brackets, and hardwood pins and then towed to the mill by tugs.

For many years rafts on the Mississippi and some other rivers in the Lake States were made into "brails" or sections. The logs were fastened together with poles in a manner similar to the Ohio River method, except that rope and rafting pins were used instead of chain dogs. Two-inch holes were bored in the log on either side of the pole and the ends of a short section of rope placed in these holes and firmly held by hardwood rafting pins driven in behind them. This was an expensive method because of the large amount of rope required, and it has now been superseded by an improved method patented by an employee of one of the boom companies.

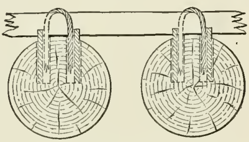

Fig. 119. — Method of fastening Rafting Poles to Logs by means of Rafting Pins. A method formerly used on the Mississippi River.

The brails as now made consist of a set of boom sticks forming a rectangular pocket which is filled with loose logs. The boom sticks are held together by a 3-link chain 10 inches long (Fig. 120, *d*) through the outer links of which the pin (Fig. 120, *b*) is passed and then driven into 2-inch holes bored in each boom stick. These pins are made of oak and turned to a minimum diameter of 2 inches and a length of 11 inches. The top end has a swell $2\frac{1}{4}$ inches in diameter, with a slightly smaller swell in the center. The head is large enough to prevent the chain link from slipping over it and the swell in the center binds on the wood and holds the plug fast. A cable is passed

through the center links around the entire brail and further strengthens it. The brail is braced crosswise with cables as shown in Fig. 120, *a*. Several links of chain are fastened, by means of a rafting pin, to the outer boom sticks on one side of the raft. On the opposite side of the raft one end of a special cable, Fig. 120, *c*, is fastened to the boom stick by a pin and the other end carried over to the chain, which is passed through a flattened link and caught. This gives rigidity to the raft.

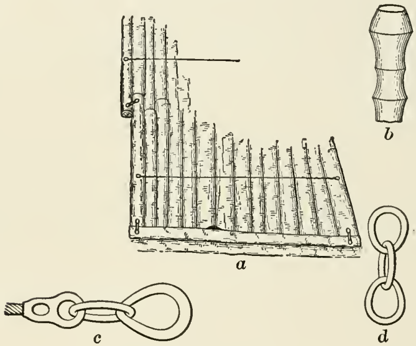

FIG. 120. — Details of a Mississippi River Log Raft. *a*. The method of fastening the boom sticks together, and bracing them with cables. *b*. A rafting pin inserted in the outer links of the chain *d*. *c*. The fixed end of the cable which is used to strengthen the raft. *d*. 3-link chain through the outer links of which the rafting pins are driven.

The chains and cables can be used repeatedly and hence are cheaper than rope which can be used but once. Rafts of this character are made up in sections, some of them 300 feet by 750 feet in size, and contain from 850,000 to 4,000,000 feet of timber. They may be controlled in the stream by an end-wheel tug boat attached to the stern of the raft. A strong double winch is placed on the bow of the boat and from this lines run to each forward corner of the raft. By hauling in on one line and slacking on the other one, the raft may be turned in any direction desired. Two tugs often are employed, one at the stern

and one at the forward part of the raft, in which case the control of direction is secured by the forward boat.

Cypress Rafts. — Cypress logs, which are skidded with pull-boats, are rafted down the canals and bayous. A common form of raft consists of cigar-shaped sections from 150 to 200 feet long, each containing from twenty to thirty logs which are floated loose within the boom sticks. Sinkers are placed between floating logs and fastened to them by poles and chain dogs. Old skidding cable is often used to bind the boom sticks together. A 2-inch hole is bored in the log, and the end of the

FIG. 121. — A Cypress Raft in a Louisiana Bayou. The floating vegetation on the extreme right is the water hyacinth.

cable inserted and made fast by a wooden plug driven in behind it. The sections are fastened together by rope, and made into a long raft which is towed to the mill by small tugs. Navigation is seriously hampered and sometimes absolutely stopped by the congestion of the watercourses by the water hyacinth and sometimes mills are forced to shut down on account of the lack of logs, due to the closing of the waterways by this plant.

Raft Bundles. — In the Coastal Plain region logs are sometimes made into bundles each containing two cars of logs (20 to 30 logs) which are bound together firmly with chains. The maximum tow for the larger tugs used on this work is from thirty to

forty bundles. From 30 to 40 per cent of the timber cannot be floated and the object of this method of transportation is to make the floaters carry the nonfloaters. Bundles frequently have to be made over because of an excess of heavy logs which

FIG. 122. — A Raft Bundle at the Mill Pond. North Carolina.

causes them to sink. The bundles are constructed at a log dump built over some tidal stream. A cradle of two heavy cables is used to bundle the logs. One end of the cable is fastened to the railroad trestle, and then passed down under the water and up to

a winch located in the second story of the log dump. The cables thus make a large loop into which the logs are unloaded. Two binding chains are sunk into the water alongside each cable, one end being temporarily attached to the unloading dock and the other end to a small rope which is placed outside of the cradle. When the logs have been placed in the latter, the bundle is made compact by tightening up the cradle cables, and the binding chains are then brought around the bundle, tied and made fast by heavy iron dogs.

Pacific Coast Rafting. — Logs in the Pacific Coast region are often rafted down the large streams, or towed along Puget Sound to the mills. Two forms of rafts are employed for this work. When logs are to be floated downstream without the aid of a tug, they are made up into "round" booms which consist of a group of loose logs surrounded by several boom sticks. The raft is allowed to drift with the current, and may or may not be in charge of a raftsman, depending on the character of the stream, and the tides.

Logs that are to be towed to destination are rafted at a "harbor boom," which consists of a large storage pocket and a rafting pocket. The logs are brought to the harbor boom by rail and dumped into the storage pockets which consist of an area inclosed by boom sticks held in place by piling. The rafting pockets are narrow lanes about 75 feet wide and from 800 to 1000 feet long inclosed by boom sticks, held in place by piling placed at approximately 70-foot intervals. The logs may or may not be sorted for quality and species previous to rafting. Rafting on tide water can be carried on only during a favorable tide.

The rafters first string boom sticks across the far end and on both sides of the pocket. Logs of approximately equal lengths are then poled down the run and stowed parallel to each other in the first section of boom sticks. Each row is known as a "tier," and two tiers usually constitute a section about 75 feet square. As soon as two tiers have been stowed logs, called "swifters," are placed across the end of the section at right angles to the tiers in order to keep the logs closely packed. The gap is then closed by a boom stick placed across the opening and

attached to the boom sticks on the outer side of the raft. New sections are then made up in the same manner, twelve to fourteen constituting the usual tow. Two rafters can make up about six sections or from 260,000 to 300,000 feet during a tide.

When the rafting is done in rivers where there is a strong current a slightly different procedure is followed. The rafters start at the near end of the rafting pocket and hang out three or four sections of boom sticks. The logs are then run in the rafting pocket and guided with a pike pole to their place in the "tier." Great difficulty is experienced in turning logs end on in a swift current, if they get crosswise of the rafting pocket. In case piling is not used to confine the rafts, each section is kept from spreading until completed by the use of a rope or cable also called a "swifter" which is fastened to the outside boom sticks. When the sections are completed the "swifters" are removed.

The cost of unloading and rafting logs is approximately 10 cents per thousand feet, and the cost of towing to the mill averages 1 cent per mile for each thousand feet.

OCEAN RAFTING

The first attempt at rafting logs for transport on the high seas was made about 1884 when a large raft was constructed in Nova Scotia, launched from shore and started toward New York in charge of a tug. This raft was lost because the tug left it to go into port for coal and on return to the high seas was unable to again locate it. After a long period it washed ashore on the Norwegian Coast. The same builder later went to Coos Bay, Oregon, where he built two rafts for transport to San Francisco, one of which reached its destination safely. In the construction of the latter rafts the use of cradles or floating frames was first adopted.

In 1894, raft building began on the Columbia river, where it has reached its highest development. Several rafts now leave annually for San Diego, California, with no losses during recent years. The rafts are built cigar-shaped and from 700 to 1000 feet long, with a depth at the center of from 30 to 35 feet and

a breadth of from 50 to 60 feet. The taper extends 100 feet from each end.

Ocean-going rafts are built in a cradle or frame which is moored to piling in deep water. One side of the cradle is detachable and when the raft is completed it is launched by dropping this side and allowing the raft to slide sidewise into the water. A 700-foot cradle requires 200,000 feet of timber in its construction, and costs about $5000. With minor repairs it can be used for an indefinite period. A derrick hoisting engine, mounted on a scow, and valued at $5000 is necessary for stowing logs in the cradle. A crew of five or six raftsmen is required.

The logs are floated out to the cradle and, beginning at either end of the latter, the longest and most pliable sticks are used for the outer layers. These sticks should be at least 60 feet long and are placed with their butts toward the center of the raft. This gives a taper to the body of the raft and as the logs gradually work outward the binding chains are drawn tighter. The interior may be filled with any length logs, provided the joints are broken.

After the raft has been built up to a height of 20 feet, a $2\frac{1}{4}$-inch tow chain is laid from stem to stern with 50 feet projecting on either end to which the towing cable is attached. "Herring bone" chains, made from $1\frac{3}{4}$-inch iron, are then attached to the main tow chain on the tapering ends of the raft, run diagonally across the raft toward either end, and fastened to the binder chains. This prevents the latter from slipping on the conical portion of the raft, distributes the pull of the tow chain over a large portion of the stern, and also gives a limited amount of slack in the center, which is essential to permit the raft to bend slightly with the action of the waves.

When the raft is completed, binder chains made from $1\frac{3}{4}$-inch iron are placed entirely around it at 12-foot intervals and are tightened by the hoisting engine. A 700-foot raft containing from 4,000,000 to 5,000,000 feet requires about 115 tons of chain, which, with accessories, is valued at $10,000. A 30-foot raft draws from 20 to 22 feet of water and can be towed to San Diego, 1200 miles, for $1 per thousand feet.

The safe towing periods are from June 15 to September 15 and, under favorable conditions, the trip can be made in from eighteen to twenty days.

LOG BARGES

Barges are used for the transportation of hardwood logs on some portions of the lower Mississippi River, the logs being brought to the banks of the stream and loaded by power derricks. Barge transportation is desirable on streams where suitable rafting facilities are not available and with species that are too heavy to float. Although introduced in the Lake States, this method never gained much favor in the transport of logs from Canada to the United States, because of the limited capacity of the boats, and the ease and safety with which logs could be rafted.

SUNKEN LOGS

Many streams, on which driving has been carried on for years, have accumulated great numbers of small, heavy butted and sappy logs in their channels. In the Lake States streams, which contain immense quantities of sunken timber, the "deadheads" average about twenty logs per thousand feet, log scale.

Numerous efforts have been made to salvage sunken timber, especially in this region, and although log-raising companies have been formed and have operated to a limited extent, the industry has never assumed large proportions. The obstacles in the way of successful operation have been numerous. According to a decision[1] of the Supreme Court of Michigan the title to sunken logs remains with the original owners. Where several hundred marks and brands have been used on a stream, it is almost hopeless for a company to attempt to secure title to all the timber raised because many of the owners of given brands and marks are deceased or have left the region. In addition the log raiser must reckon with riparian owners which is a further drawback to the work.

There have been numerous methods used in raising logs, some of which have been patented. On shallow streams they

[1] See page 371.

are often raised by workmen who use pike poles and operate from boats. The logs are towed to land, where they are stored until thoroughly dry, when they are again put in the stream and rapidly driven to their destination.

A hoisting engine with suitable booms and grapples, mounted on a flat boat, has also been used. The logs were frequently rafted and kept afloat by steel tubular buoys 32 feet long by 18 inches in diameter which were scattered throughout the raft. Occasionally deadheads were attached to rafts of floating timber and thus buoyed up until they reached the mill.

White pine deadheads have been sold for as much as $5 per thousand as they lie in the stream, although the average price is approximately $4 per thousand feet, log scale.

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CHAPTER XXIII

FLUMES AND LOG SLUICES

Log and lumber flumes, and log sluices are built to transport lumber, crossties, shingle bolts, acid wood, cordwood, pulpwood, mine timbers and saw logs from the forest to mills, railroads or driveable streams, and to carry products from the mill to market, or to rail transport. They are used to a limited extent in every forest region, but are especially serviceable where stream transportation is not available and when the topography renders railroad construction costly. They are most commonly employed for handling sawed products, although they are now being used in some parts of the West for transporting mine timbers and saw logs.

They have several advantages over logging railroads in a rough region: (1) they can be carried over inequalities in the ground, or across gulches on fairly light trestles; (2) they can be operated on steeper grades; (3) they occupy less space than a railroad and hence require smaller cuts and tunnels and can often be located in narrow canyons where there is not sufficient room for a railroad.

The disadvantages are: (1) the transport of crooked and long logs is difficult and costly; (2) the light construction renders them more subject than railroads to damage by windstorms, fires, floods, falling timber and other natural agencies, although they can be repaired more cheaply; (3) they usually offer no means of transporting supplies from the railroad to the mill or forest; however, in one instance the edges of the flume box were used as a track over which railroad speeders were run, thus affording ready communication between the two ends of the flume; (4) the transport of lumber roughens the surface of planed material and also batters the ends of the boards which have to be trimmed after leaving the water so that planing mill

work must be done at some point below the flume, often leading to increased cost of manufacture.

LOCATION

Flume routes are best located by engineers who have specialized on logging. The practice followed by some successful flume builders is to locate the route with a transit and set stakes as for a railroad survey. Levels are then run and plotted and the grade line established, the latter being the cut-off height of the trestle bent which is the bottom of the cap. Center stakes for the bents are established at proper intervals, and following this the grade stakes are set for the batter-post mud-sills. The data for the base of each trestle bent are calculated for the use of the constructors, and show the length of the two lower sash braces, the distance along the batter posts, and the length each batter post must extend below the first sash brace in order that the trestle may stand plumb on the mud-sill. The calculation of the length of each sash brace is important because it governs the batter of the posts and if it is not properly calculated the spacing between the posts under the cap will vary.

Careful consideration must be given to curves and the maximum degree of curvature must be determined for the longest material that is to be handled. The following table[1] of curvatures for flumes is regarded as safe.

Maximum length of material to be run.	Safe maximum degree of curvature.
Feet.	Degrees.
8	20
40	10
60	8
80	6
100	4

Curves at the base of steep grades should be avoided, because jams will form which will not only damage the flume but will

[1] From Lumber Flumes, by Francis R. Steel, Bul. of the Harvard Forest Club, Vol. 1, 1911.

also cause the lumber to leave it. The maximum degree of curvature permissible increases with the grade but diminishes rapidly as the grade falls under 3 per cent. The following table[1] of minimum grades is considered safe.

Degree of curve.	Safe minimum grade.
	Per cent.
Straight	0.5
4 degrees	1.0
6 degrees	1.5
8 degrees	2.0
10 degrees	2.5

The most desirable grades for a straight flume are 3 per cent or more. Grades up to 75 per cent may be employed on short stretches, provided all sharp changes in elevation have properly proportioned vertical curves.

TYPE OF BOX

There are two general types of flume and sluice boxes. One is V-shaped and may have a "backbone"[2] which makes a box 6 or 8 inches wide at the base, with outwardly sloping sides. The other is known as the box flume.

The choice of type and size of box depend on the character and size of material to be transported, the amount of water available, and the ultimate use of the water itself. In some instances when water from flumes is used for irrigation purposes, the box is of larger size than is required for the sole purpose of transporting forest products.

Lumber and log flumes rest on skids on the ground or are elevated on trestles. They sometimes pass through tunnels or cuts although these are avoided whenever possible because of the increased cost of construction.

V-box. — This type of box is commonly employed for lumber, crossties, small dimension stock, small round mine timbers,

[1] From Lumber Flumes, by Francis R. Steel, Bul. of the Harvard Forest Club, Vol. 1, 1911.

[2] A triangular strip fastened in the vertex of the flume box.

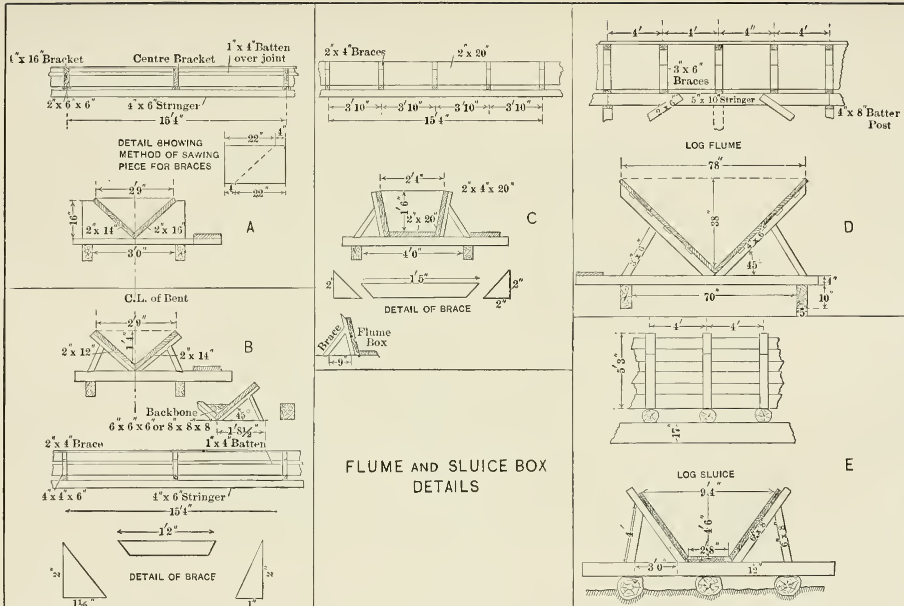

Fig. 123. — General Structural Features of Flume and Sluice Boxes. *A* and *B*. V-boxes for lumber, dimension stock and crossties. *C*. Box for shingle bolts, pulpwood and small logs. *D*. V-box for logs. *E*. Sluice box for logs, used in stream improvement work.

pulpwood,[1] and, when built of large size, for saw logs.[2] With a backbone it requires less water than any other type.

A box with a vertex angle of 90 degrees is regarded as the most desirable since this angle permits the cheapest construction because the joints can be fitted more easily and the lumber used to better advantage.

An objection sometimes raised to the use of a V-box for the transport of shingle bolts and like material is that the individual pieces are uneven in size and weight and do not all travel at the same speed, therefore they are apt to double on low grades and on curves.

The V-flume with a backbone is considered the more desirable form for a mixed cut of lumber and dimension stock. The capacity of a flume of this character does not exceed 100,000 feet daily, with an average of from 40,000 to 50,000 feet.

The box of a V-flume for lumber and crossties has sides ranging from 15 to 18 inches high and is from 30 to 36 inches wide at the top (Fig. 123, *A* and *B*). The backbone when added is made from a 6- by 6-inch or 8- by 8-inch timber sawed diagonally. The side boards of the box are 1 inch in thickness for sides up to 30 inches in height, $1\frac{1}{2}$ inches if from 30 to 36 inches high, and 2 inches if from 36 to 48 inches high. The cracks are battened with 1- by 4-inch or 1- by 6-inch strips. The boards range in width from 8 to 14 inches, but are usually

[1] A pulpwood flume operated in the Adirondack Mountains of northern New York was 36 inches across the top and 36 inches deep. It was supported on a trestle which in places was 100 feet high. The flume was $2\frac{1}{2}$ miles long, had a capacity of sixty cords of 18-inch pulpwood per hour, and the bolts traversed the distance in $7\frac{1}{2}$ minutes, dropping into a stream down which they were driven to a pulp mill.

[2] A 5-mile log flume (Fig. 123, *D*) was recently constructed in Idaho with an average grade of 11 per cent, a maximum grade of 15 per cent, and a maximum curvature of 20 degrees. The box was supported on trestles 16 feet apart with 4- by 8-inch sills, posts, and caps and 2- by 6-inch braces; 5- by 10-inch stringers with 2- by 6-inch lateral braces and round pole supports in the center of each bent; 4- by 6-inch bracket sills spaced from 2 to 4 feet apart depending on the weight carried and the strength required at loading points, and 3- by 6-inch braces. The box was made from 2-inch rough lumber with the cracks battened with $1\frac{1}{4}$- by 4-inch strips. The cost of the flume complete was about $8,000 per mile. See The Timberman, August, 1912, pp. 42–44. See note on page 411.

from 12 to 14 inches. The lengths are commonly 16 and 24 feet.

Box Flumes. — These are used for lumber and dimension stock (Fig. 123, *C*), shingle bolts, pulpwood and logs.[1] They are more expensive to construct than a V-flume because the greater weight of water carried necessitates a heavier trestle. Where

FIG. 124. — A V-Flume for transporting Mining Stulls. Montana.

the water supply is abundant, boxes of this character are sometimes used for lumber transport. A box flume[2] in California

[1] See note on page 412.

[2] This flume was started in 1891 by the Fresno Flume and Irrigation Company for irrigation purposes and now is 65 miles in length, connecting the sawmill at Shaver with the planing mill and shipping depot at Clovis. Near the head the flume box is rectangular and has sides 12 inches high and a width of 48 inches. On the steep mountain pitches the sides are 32 inches high, and on the lower end 48 inches high. The maximum grade is $4\frac{1}{2}$ per cent and the minimum grade on the flats 0.5 per cent.

transports 300,000 board feet daily, a quantity three times as great as the maximum for a V-flume. This increase is made possible by clamping[1] from five to six boards together into a unit which is floated singly on the steeper grades toward the head of the flume. On the low grades near the lower terminus from twenty-five to thirty units are "dogged" together with manila rope and floated to destination.

For shingle bolts, acid wood, and cord wood a box with a 10-inch bottom, 20-inch sides and 24 inches across the top is sometimes employed. In northern New York a flume of this size handled sixty cords of spruce pulpwood per hour. As a rule, however, they are larger with a base of approximately 20 inches, sides from 16 to 20 inches high and a width across the top of from 30 to 32 inches. The boxes are supported on trestle work similar to that used for the V-flume, although the construction is stronger.

The boxes of log sluices (Fig. 123, *E*) are of larger size than those for lumber flumes and carry more water. They are used chiefly to supplement stream driving by transporting logs through rocky gorges where an excessive amount of water would otherwise be required or where boulders prevent the profitable improvement of the stream for loose driving, and for transporting logs over stretches of streams whose banks are so low that the flood waters scatter the logs over the lowlands. They are also used in connection with log haul-ups to transport logs from one watershed to another, and, in some cases, to transport logs directly from the forest to the mill. They have been employed frequently in the Lake States and occasionally in the Northeast.

On account of the large amount of water they must carry to float logs and because of the wear-and-tear they receive, the boxes are made of strong material supported on cribwork which is kept as near the ground as is feasible.

[1] The clamp which is patented is a bar of $\frac{1}{2}$-inch half-round iron, with a 1-inch flat face having recurved points at each end. The boards are made into piles with the ends flush with each other, a clamp is slipped over the end, and a wedge driven between two boards near the center of the unit. This drives the points into the outer boards and binds the whole load together.

Sluice boxes are sometimes made with two thicknesses of 2-inch plank, the inner set being surfaced and tongued and grooved to insure a tight joint, while the outer set of plank break joints with the inner and make a tight box. The dimensions of a sluice of this character built in the Lake States for white pine were 36 inches in width at the base, 108 inches wide across the top, and 60 inches high. The water in the sluice was controlled by half-moon gates (Fig. 102), located at the mouth of storage reservoirs.

TRESTLES

Trestles may be built of round timber or of 2- by 6-inch or 4- by 8-inch sawed material. Flumes used for transporting sawed material usually have a trestle made from square-edged material, because it can be secured at the mill and transported to the place of construction in the completed portion of the flume. Where logs, pulpwood, acid wood, and other rough material are transported from the forest to the manufacturing plant, round timber from 8 to 12 inches in diameter is often used for trestle construction for it can usually be secured in the vicinity, although some prefer to erect a portable sawmill at the head of the flume and manufacture lumber for its construction.

Caps for round timber trestles are either made from small timber hewed on opposite faces to the desired thickness or from sawed material. Stringers are usually made from sawed timber. The braces for round timber trestles are made from small poles.

For square-edged timber trestles caps are made from 2- by 6-, 4- by 4-, or 4- by 6-inch material, and stringers from 4- by 4-, 4- by 6-, or 6- by 6-inch timbers, the choice depending on the size of the box, the distance between trestle bents and the amount of water carried.

Braces for the box are placed along the stringers at 2-, 4-, or 8-foot intervals, depending on the length of the span, the form of the box,[1] and the strength required at special points, such as

[1] A V-box with a backbone for fluming lumber requires bracing only at 8-foot intervals, while a box flume should have braces every 4 feet on a 24-foot span. Loading points on log flumes are often braced at 2-foot intervals.

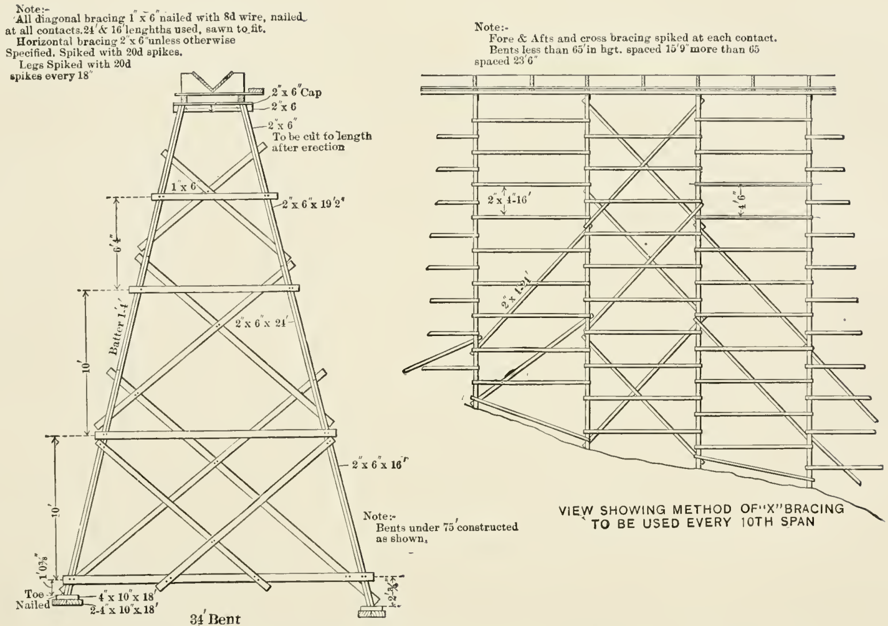

FIG. 125. — Details of a Trestle Bent for a Lumber Flume; also the Method of Cross-Bracing the Bents.

loading stations. They may be made from 2- by 4-inch joists or from solid 4-inch blocks (Fig. 123, *A* and *B*).

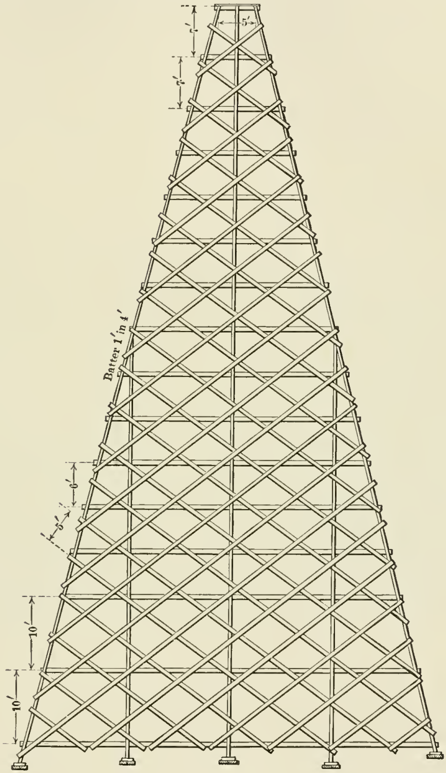

FIG. 126.—A Five Leg Trestle for Heights Greater than 75 Feet.

A practical type of trestle[1] for a lumber flume under 75 feet in height consists of two legs made from 2- by 6-inch joists, doubled and braced (Fig. 125). For heights greater than 75 feet a trestle with five legs is used (Fig. 126).

[1] Designed by F. M. Kettenring, C. E., Vancouver, Washington.

Two 4- by 6-inch stringers rest on the caps which are spiked to the trestle. Solid braces which support the sides of the V-box are placed on the stringers at 8-foot intervals. The details of the brace and other features of the box are shown in Fig. 123, *A*.

TERMINALS

Flume terminals are of several different types. The choice is dependent largely on the kind of material handled and its

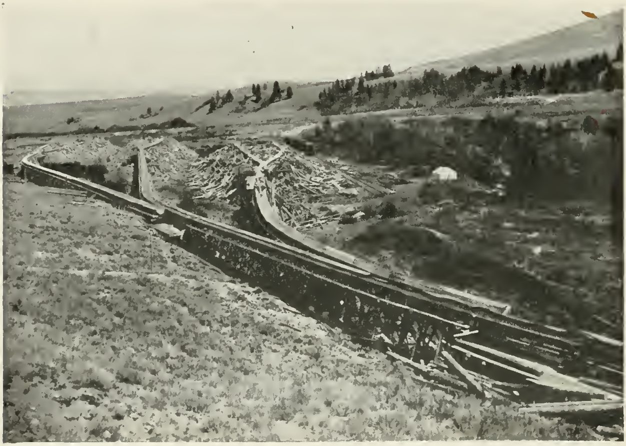

FIG. 127.—The Terminal of a Log Flume, near the Deerlodge National Forest, Montana. This type is known as an "elephant."

disposal at destination. Logs, pulpwood and rough stock are often dumped into streams, thus obviating the necessity for any special form of terminal.

On the Allen flume[1] in the Deerlodge National Forest in Montana round mining timbers are transported to a storage depot where they are loaded on cars and hauled to destination. The flume is about 20 feet high at the dump and the logs are shot out onto rollers on a platform. These carry the logs to the point

[1] See note on page 413.

where they are rolled onto cars. The water from the flume falls onto a waterwheel which drives the rollers when the latter are thrown into gear.

Another type of terminal, known as the "elephant," is shown in Fig. 127. The flume forks several times near the terminal and forms branches. Logs are diverted into a given branch by closing the branches not in use, and the logs are run out to the end of the terminal and fall in a rough-and-tumble heap below.

The type of terminal shown in A, Fig. 128, is often used when lumber is dumped on platforms or loading stations. Lumber shoots out from the end of the flume and piles up on the platform at the base of the terminal. When one side becomes filled the shunt board is turned and the lumber diverted to the opposite side.

A form of terminal similar to *B*, Fig. 128, may be used for crossties and heavy timber. The timbers are removed by hand from the rollers and piled on the unloading platform or on trucks.

CONSTRUCTION

The general methods of constructing a V-flume are illustrated by one built in Washington for the transport of 40,000 board feet of lumber and crossties daily. The product to be handled ranged in length from 8 to 32 feet.

The flume had a maximum height of 128 feet, maximum curves of 8 degrees, and a 3 per cent grade on the upper part and 0.66 per cent on the lower end. Lumber floated at the rate of 3 miles per hour.

Bents were placed 15.75 feet apart for heights of 65 feet and under, and 23.5 feet apart for heights in excess of this. The batter posts on all trestles under 75 feet were spaced 4 feet apart at the cap, and for heights greater than this 5 feet. The batter in all cases was 1 in 4. In the bent construction only three sizes of lumber were used, namely, 1- by 6-inch, 2- by 6-inch, and 2- by 4-inch, the latter being used for the fore-and-aft bracing. As a rule only 16- and 24-foot lengths were used, because this simplified the work, reduced the time lost in handling, and very little lumber was wasted. A "select common" grade of

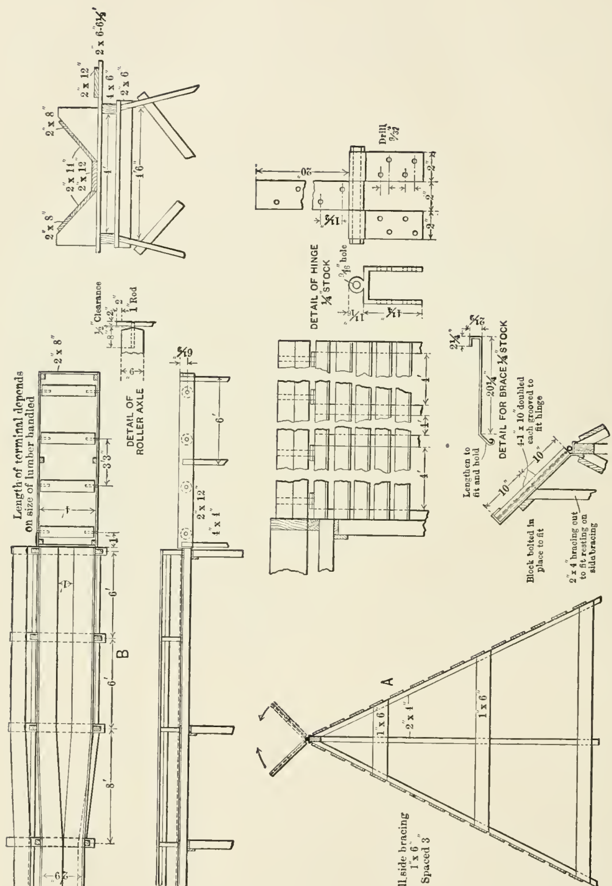

FIG. 128. — Two Types of Flume Terminals. *A*. For lumber. *B*. For crossties, heavy timbers, planks and scantlings.

lumber was used, which was worth $12 per thousand. The first 24 feet of each bent was framed on the ground, the foot of each batter post being laid on or near the mud-sill on which it was to rest. Bracing was made from 1- by 6-inch and 2- by 6-inch material. When ready, the bent was hoisted in place, and set on the mud-sills by the aid of a block and tackle attached near the top of the nearest bent. When in position it was plumbed up and spiked to the mud-sill. A 2- by 6-inch by 16-foot timber was then placed against the outside of each post and securely nailed to it with 20-penny spikes. Fore-and-aft braces (Fig. 125) were then nailed on until the top of the 16-foot post was reached when another 2- by 6-inch by 16-foot timber was set on top of the first post with a lap of 8 feet on the inner one. More fore-and-aft braces were then placed. The addition of 2- by 6-inch by 24-foot scantling continued, with proper bracing, until the cut-off height was reached. On the 15.75-foot span a block and tackle was used on each batter post for elevating the material when the height became too great for handing it up. On the 23.5-foot span lines were also hung on the rear bent to aid in raising the 24-foot fore-and-aft braces.

The cut-off point of the bent was established only when several hundred feet of trestle had been built. A wye level was then placed on a staging built on top of a bent and the line of levels established by it. The 2- by 6-inch caps were elevated and placed in position as soon as the posts were cut off.

Cross-bracing was put on after several hundred feet of trestle was erected (Fig. 125). Bents exposed to the wind were also strengthened by wire guys.

The construction crew consisted of from six to eight men, four of whom worked aloft continuously. On low work one man handled and sent up all lumber and another was engaged in framing the lower sections.

The lumber was hauled as near as possible to the point where it was to be used, and was sorted and piled where it could be reached with the least delay. One man built the boxes in 16- or 24-foot sections at the upper end of the flume, placed the brackets inside each section, and placed it and the 4- by 6-inch

stringers and the foot planks in the flume ready to float to the front. A man walked the flume and kept the material moving.

Two top men at the front placed the stringers and foot planks in position, trimmed the boxes, set them in place, adjusted the brackets and nailed them to the boxes. A crew of four men placed from twenty to twenty-five 16-foot sections in ten hours. This did not include an 8-inch top board on the box which was not added until the remainder of the flume box was complete.

Cost of Construction. — The cost of flumes is governed by the location survey charge, by the labor charge, which depends chiefly upon the height of the flume, by the values of the material, and by the cost of transporting the supplies to the flume site.

AMOUNTS OF LUMBER, NAILS AND DAYS' LABOR REQUIRED TO CONSTRUCT LUMBER FLUME TRESTLES OF VARIOUS HEIGHTS

	Height in feet.							
	10	15	20	25	30	35	40	45
Lumber, board feet	....	....	75	125	200	350	500	600
Nails, pounds	1.0	1.75	2.0	3.75	5.0	7.0	9.5	10.5
Labor, days	0.10	0.10	0.10	0.20	0.40	0.50	0.60	0.70

	Height in feet.						
	50	55	60	65	70	75	80
Lumber, board feet	750	1000	1300	1500	1750	2000	2150
Nails, pounds	12.0	17.0	20.5	25.0	31.0	35.0	40.5
Labor, days	1.00	1.30	1.60	1.90	2.30	2.70	3.10

	Height in feet.						
	85	90	95	100	105	110	115
Lumber, board feet	2350	2550	2750	3000	3250	3450	3850
Nails, pounds	47.0	51.0	57.0	61.5	76.0	90.0	112.0
Labor, days	3.90	4.8	5.5	6.25	7.00	7.70	9.00

The cost of engineering work is from $100 to $140 per mile; and the cost of construction, including labor, material and right-of-way, from $1000 to $3000.[1]

Labor on flume construction averages from 30 to 40 cents per hour for men who work aloft and from 25 to $27\frac{1}{2}$ cents for ground men.

The number of days' labor, the pounds of nails and the thousand board feet of lumber required to build trestles[2] of specified heights and of the types shown in Figs. 125 and 126 is given in the preceding table.

The construction of the box and foot-boards required 68,485 board feet of lumber and approximately 2800 pounds of nails, per mile. The cost of box construction averaged $320 per mile.

The average cost of short lumber flumes where high trestles are not required and no special difficulties attend the work, does not exceed from $1200 to $1400 per mile; log flumes cost from $6000 to $8000 per mile; and log sluices from $2000 to $4000. On the other hand certain sections of a flume built in the Big Horn mountains of Wyoming for bringing out crossties, mine timbers, and lumber cost $9000 per mile for four miles, and $5000 per mile for an additional five miles. The high cost of construction was due to the difficult engineering problems involved, including the construction of two tunnels, heavy trestles and the building of the flume along the precipitous sides of gorges.

Several box and V-flumes,[3] in California, which extend for distances of from 50 to 70 miles, have cost $5000 and upward per mile.

[1] See Lumber Flumes, by Francis R. Steel. Bulletin of the Harvard Forest Club, Vol. 1, 1911.

[2] Designed by F. A. Kettenring, C. E. Vancouver, Washington.

[3] A V-flume with 36-inch sides and a width across the top of 46 inches was built in 1899–1900 in California, by the Madera Sugar Pine Company. The flume was originally $53\frac{5}{8}$ miles in length and cost $275,000 to construct, an average of $5000 per mile. Approximately 5,700,000 feet of redwood lumber and 2100 kegs of nails were used in construction. The maximum grades were 18 per cent and lumber traversed the flume at the rate of 6 miles per hour. The daily capacity is approximately 100,000 feet.

OPERATION

The amount of water required for a flume depends on the size of the box, the grade and the amount of leakage. On steep grades a flume requires less water than on low grades because the flume box becomes a wet slide and the logs run freely with very little water. The age of the flume and the care with which it is maintained largely determine the amount of leakage. Forest Service officials found that on the Allen flume in Montana which carries from 5 to 12 second feet of water the leakage averaged 0.3 second feet per mile. They estimate that the average leakage in a flume in good condition, carrying 5 to 10 second feet of water, will approximate 0.45 second feet per mile.

Water is admitted from ponds or branch flumes at the head of the main flume and also from feeders or troughs located at numerous points along the route. These feeders run from the main stream or some of its branches. If the water supply is limited, every effort is made to keep the flume box tight to prevent waste. This is not so essential, however, where water can be turned in at frequent intervals.

The products are placed in the flume boxes by various means. Sawed lumber and crossties are usually shunted into the flume from an incline at the tail of the mill. Pulpwood and acid wood are frequently rolled or thrown into the box from skidways or floated in from ponds; while logs may be rolled in from skidways, floated in from artificial storage ponds, or elevated by log loaders. The use of ponds is the simplest and cheapest method, while the use of a log loader is the more expensive.

Flumes are operated by crews that feed the flume; by runners who are stationed at points along the route where jams are apt to occur; and by laborers who handle the product at the terminal. The runners usually carry a pick-a-roon to aid in handling the floating material. The size of crew required depends entirely on the character of the flume, those with many curves and low grades requiring the most runners.

On the Allen flume in Montana, which is about 16 miles long, thirty flume tenders are required for handling about 3500 mining stulls and logs daily. Four men feed the flume and twenty-six

men patrol it, the greater number being required where the flume crosses the Continental Divide on a very low grade. The daily cost of operation is $90, an average of 77½ cents per thousand feet.

On the American Gulch flume[1] in the same section five men are required on a flume about one mile long. Two men feed the flume and three men act as patrols. The daily run averages from 800 to 1100 mining stulls and the cost of operation varies from 80 to 95 cents per thousand feet.

A box log-flume, in Oregon, three and one-half miles long, handles an average of 150,000 feet daily. Ten men are required to operate the flume and the cost is 25 cents per thousand for labor and 5 cents per thousand for depreciation.

NOTES TO CHAPTER XXIII

Page 398. The log flume shown in Fig. 123, *D*, requires the following material per mile for construction where the trestle legs are 7 feet in length.

LUMBER		NAILS	
Purpose for which used.	Quantity.	Size.	Quantity.
	Board feet.		Pounds.
Mud sills:	13,200	12 penny	1700
Posts	19,140	16 penny	1075
Caps	9,240	20 penny	390
Cross braces	7,260	40 penny	3625
Lateral braces	6,600		
Stringers	42,240	Total	6790
Brackets:			
Sills	18,480		
Braces	7,095		
Arms	23,880		
Box boards	96,800		
Battens	17,600		
Bracket sills	2,640		
Running boards	10,560		
Waste in construction	11,265		
Total	286,000		

Page 399. A box flume 3½ miles long for the transportation of logs is in use in Oregon. The problem confronting the operator was to transport timber out of a rolling plateau region down to a mill several miles distant. Owing to the rough character of the country the cost of railroad construction was prohibitive. The engineering problems encountered were not easy to solve because the water supply during the lowest stages did not exceed 100 miners' inches and extraordinary efforts had to be made to conserve it. Some canyons from which timber was to

[1] See note on page 413.

be transported had no available water in them and it was necessary to build the flume from one watershed to another to get the timber out.

The preliminary work consisted of a survey of the whole route and a very careful determination of the levels. The construction work was begun at the mill and carried forward each year as required to secure the requisite amount of timber. The first section of the flume was built nearly on a dead level, but as the work progressed a grade of 1 inch in 100 feet was given.

The natural gradient greatly exceeded that given to the flume and it was necessary to build the latter in three units, each ending in a V-shaped chute which led from the flume to a pond at a lower elevation. These ponds were about 75 by 100 feet in size and were located at points where the natural conditions favored their construction. They not only served as a storage reservoir for water and a point for the change in grade of the flume but also as a place for logs to enter the flume.

The grade line was kept as near the ground as possible in order to avoid expensive trestle work and cuts. However, some cuts could not be avoided and trestles had to be built when the flume crossed canyons or other depressions.

The flume box was constructed of 2- by 12-inch plank and was 6 feet wide and 4 feet deep, except on sharp curves where it was wider. The normal depth of the water was $3\frac{1}{2}$ feet. Trestles were built of sawed timbers and braces of the same size timbers were placed along the box at 3-foot intervals. A running board extended along one side of the box for the use of flume tenders. Lumber for building the flume was cut in a portable mill which was kept as near the actual construction point as was practicable. This reduced the charge for transport of flume material. Each flume unit was provided with three lift gates suspended from the center of a beam which was supported by two upright posts placed on either side of the flume. One gate was used for the control of the water and the other two for emergency purposes. Should an accident happen to the gate in use, or a log become jammed in it, one or both of the others could be closed and a waste of water prevented. The gates were opened by lifting them with a lever until they cleared a 2-inch cleat nailed across the bottom of the flume when the force of the water raised them to a horizontal position. They were then supported by 2- by 4-inch joists, which were placed across the flume.

In the spring of the year an abundance of water was available and a slight current was created in the flume by keeping open a small extra gate. During this season the logs were floated loose and only an occasional man was needed to keep them moving and to prevent jams. In the summer and fall the water was at a low stage and the logs were dogged together in strings of from 50 to 75 (10,000 to 15,000 feet, log scale) and were towed along the flume by a man who traveled the running board. The opening of the large gates also created an artificial current which assisted in keeping the logs moving. The tow was kept as near the gate as possible and when the latter was opened the logs were rushed through to get the maximum benefit from the accumulated head.

The flume was built at a cost of $3,000 per mile and it is estimated that with minor repairs, it will last for fifteen years.

It will handle a 50-inch log, or two 30-inch logs side by side, except where the latter pass through the gates. The logs run three to the thousand feet, log scale, and the average daily capacity of the flume is 150,000 feet. Twenty-four million feet have been handled in seven and one-half months.

Page 404. The Allen flume has a 34-inch V-shaped box, the angle at the vertex being 63 degrees. The box is made of six boards 16 feet long, five of which are $2\frac{1}{2}$ by 11 inches, and the sixth $2\frac{1}{2}$ by 12 inches. The cracks are battened by 1- by 4-inch strips. A 6- by 6- by 6-inch backbone is fitted into the vertex. The box is supported on trestle work, composed of 4- by 4-inch uprights, braced diagonally with two 2- by 4-inch timbers, on top of which is a 4- by 4-inch cap. The trestles range in height from 2 feet to 72 feet, the longest one being 775 feet. The flume box is braced by 2- by 4-inch timbers placed against the sides of the box and supported by other timbers of the same size. These timbers rest on the caps.

Water is supplied both from a reservoir at the head, and by numerous flume feeders placed along the route which is about 15 miles in length.

The grade varies from 0.5 per cent to 12.5 per cent.

There are twenty rock cuts from 8 to 20 feet in depth and one tunnel 685 feet long.

The flume has a capacity of 3500 logs daily, an average of 116,000 board feet.

The fluming season is about five and one-half months.

The cost of construction was approximately $4000 per mile, and at the end of four years $500 per mile were expended in repairs on ten miles of flume.

Page 411. The American Gulch flume, approximately 1 mile in length, in the Deerlodge National Forest in Montana, has a 30-inch V-box which is chiefly supported on stringers laid on the ground. Very few trestles are employed. The flume can handle mining stulls 15 inches in diameter and from 14 to 16 feet long. Thirty-three thousand feet of lumber at $24 per thousand delivered, and 2755 pounds of nails were used in the construction of the box. Seven men built a mile of flume in twenty days at the following reported cost per mile.

Supplies and labor.			Cost.
Lumber:			
Stumpage at $4.00			$132.00
Logging, manufacture and hauling at $24			792.00
Nails:			
2755 pounds at 5 cents, delivered			138.00
Labor:			
1 man at $4 per day	$ 4.00		
6 men at $3 per day	18.00	$22.00	
20 days' labor at $22			440.00
Total per mile			$1502.00

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PART V

SUMMARY OF LOGGING METHODS IN SPECIFIC REGIONS

CHAPTER XXIV

A. PORTABLE MILL OPERATIONS

Although the annual cut of a portable mill ranges only from several hundred thousand to a few million feet, the industry is of importance because of the large number of plants in operation many of which handle timber in regions where large mills are not feasible.

As a rule the portable operations in New England are conducted as a side line by men engaged in the retail lumber business; by contractors who can use their idle teams during the winter season; by men who engage in lumbering as a speculation when an opportunity presents itself; and by small woodworking plants which are able to secure occasional stands of timber suitable for their needs. Contract work both in logging and manufacture is common and the product is usually sold to railroad companies in the form of crossties and structural timbers; to retail lumbermen in the form of lumber; to telephone and telegraph companies in the form of poles; or to various woodworking industries. The business is more active during the fall and winter months when agricultural and other outdoor occupations are slack, because labor and teams are more plentiful and a snow bottom reduces the logging expense, especially for skidding.

In the National Forests of the West the tendency is for portable mill operators to conduct their operations continuously, except for interruptions due to climatic conditions. These operations are conducted largely in the virgin forests often several miles from a railroad and under conditions that are not favorable for the development of large plants. The products of these mills are used locally by settlers, by mines and by other industrial enterprises.

Portable plants are common in the yellow pine region of the

South. They are sometimes located on small isolated tracts of virgin timber but, as a rule, they follow large plants operating on the lightly culled lands, and old-field stands. While a portion of the product is marketed locally, large quantities are sold through the larger operators, or through wholesalers or commission men.

LOGGING METHODS — NEW ENGLAND[1]

The operations in New England are conducted chiefly on woodlots containing from fifty to several hundred thousand feet. The operation may be confined to manufacturing the stumpage on a contract basis for the owner, or a sawmill man may buy the timber outright.

A common practice is for the sawmill man to make an estimate of the property and offer a specified sum for the timber. Few care to buy on the thousand-foot basis because the chance of making a large profit is lessened. A common method of estimating in Connecticut is for the prospective purchaser to examine the tract and make a rough ocular estimate. The purchaser seldom contemplates paying stumpage on the cordwood, relying on revenue from this source as an added profit. Some take one-quarter acre sample plots and calculate the amount of timber from the data thus secured. It was formerly easy to purchase stumpage on the buyer's estimate because woodlot owners seldom had any conception of the amount and value of the timber, but in recent years many owners have hired men to cruise and value their timber.

Well-located stumpage in the vicinity of New Haven, Connecticut, now brings approximately the following prices: Chestnut saw timber, $5 per thousand board feet; standard crossties, 10 cents; 30-foot poles, $1.25; red and black oak saw timber from $6 to $8 per thousand; and white oak from $10 to $12 per thousand.

A common practice in logging virgin timber is to go over the

[1] See "Second Growth Hardwoods in Connecticut," by Earle H. Frothingham. Bulletin 96, U. S. Forest Service.

tract several times, removing certain products at a given cutting. Chestnut telephone, telegraph and electric light poles are taken out first. Piles are often cut from the tops of pole timber, if there is a market for this class of material. If there is large oak, ship timbers are generally removed next, being cut in long logs which are later sawed into flitches at the mill. The remaining timber is then converted into saw logs, the trees being utilized down to a 6-inch top diameter.

Crossties, which are cut in 8-foot lengths in the woods and sawed into squared and pole ties, are made in large quantities from short-bodied trees and large limbs.

Following the removal of all saw material comes the cutting of cordwood. The residue, down to limbs one and one-half inches in diameter, may then be cut up into material for charcoal manufacture. Near favorable markets practically all of the wood is utilized, except small branches.

The sawmill plant is set up in the immediate vicinity of the operation where an open space can be secured for log and lumber storage and where a water supply for the boiler is convenient. Camps are seldom established.

The felling crews, which work several days in advance of skidding, are composed chiefly of foreigners and from one to two saw crews of three men each are required. A three-man crew consists of a spotter and two fallers. The spotter selects the trees to be felled and notches them, lays off lengths on the felled timber, and aids the fallers in swamping. Saws and axes are used for felling. The wages for a spotter are about $2 per day and for fallers from $1.50 to $1.75. A three-man crew will fell and buck from 4000 to 5000 feet daily. The contract price for felling and log-making ranges from $1.25 to $2 per thousand feet.

Pole cutting is done by contract at a cost of from 1 to 1½ cents per running foot for felling and peeling. Peeling can be done more readily in summer and pole-cutting contracts can be let at that season for about 25 per cent less. Some buyers, however, refuse to take summer-cut timber because of the greater liability of insect attack.

Hewed ties are seldom made because of the waste in manufacture. When cut, they are made by contract at from 9 to 10 cents each for chestnut and 12 cents for oak.

Cordwood is cut and piled by contract, the price ranging from 90 cents to $1.25 for a standard cord, an average being about $1.

The logs are snaked on steep slopes, and then hauled on a log-boat, or on a "scoot" to the mill. These are used on short hauls even when there is no snow on the ground. A log-boat is about 6 feet long, 3 feet wide, and has a flat bottom made of heavy planks which are upturned in front. A bunk is placed about 4 feet from the front end and on this the fore end of the log is loaded and bound with chains, while the rear end drags on the ground. The horses are hitched to a chain which passes through the upturned nose and is attached to the bunk. A tongue is not used. The scoot is a sled having two runners about 12 feet long, with a 4-foot gauge, a forward and rear bunk, and a standard length tongue. It is especially serviceable for short logs which are loaded on the sled. Wagons are not used to transport logs to the mill unless the haul is greater than $\frac{1}{8}$ mile.

The usual log requirements of a portable mill are from 5000 to 7000 feet, log scale, daily, and on short hauls two teams can bring in this amount. The average days' work on an $\frac{1}{8}$-mile haul is about 3500 feet per team.

The contract skidding prices are about $1.50 per thousand for a maximum haul of $\frac{1}{8}$-mile, and $2 for a $\frac{1}{4}$-mile haul for saw logs; crossties 5 cents each, and posts $2\frac{1}{2}$ cents each for the shorter haul. The average cost of logs delivered at the mill, exclusive of the stumpage value, ranges from $2.75 to $4 per thousand board feet.

Skidding and hauling charges are seldom separated for poles. On a 3-mile haul, with wages and team hire at $5 per day, the cost of skidding and hauling 25- and 30-foot poles is 28 cents each; 35-foot poles 42 cents each; and 40 or 45-foot poles 83 cents each.

Cordwood can be hauled 3 miles for about $1.75 per cord.

COLORADO

The portable mill operations in this state are taken as a type of small operations in the National Forests. The mills are often several miles from a small town at rather high elevations in the forests where the topography is rugged and the snow is deep during the winter season.

The stand is largely of small-sized timber, with logs averaging from 10 to 12 inches in diameter at the small end, and from three to four and one-half 16-foot logs per tree, when cut to a top diameter of 6 inches.

The closeness of utilization depends largely on the local markets, and the purpose for which the timber is used. On some sales where waney-edge boards can be used for packing cases and other rough work, very little waste occurs, while on other sales where the demand is for lumber only, the mill waste is heavy.

The logging season depends on the climatic conditions and the character of bottom. Felling and skidding usually begin sometime between the middle of June and the first of August and continue until the first or the middle of January when snow becomes too deep for profitable work. Hauling on some operations begins at the time of felling, the logs being handled on wagons, carts or go-devils up to the time snow falls, and after that sleds are used until the end of March or the middle of April. On other operations logs are hauled only in winter.

Camps, which cost from $300 to $400 on operations of average size, are of log or board construction and comprise a cook shanty, a bunk house, a stable and possibly a few other buildings. Labor is chiefly local.

Felling and Log-making. — The methods employed are similar to those of other regions, the ax being used to notch the timber and the saw for felling. The work is done both by day labor and by contract.

The wage for sawyers is about $2.75 per day, while the contract prices range from $1.25 to $2 per thousand feet, depending on the size and character of the timber and the amount of swamping

required of the sawyers and the depth of snow. The actual cost of sawing Engelmann spruce is a little lower than for lodgepole pine because it cuts more readily; but no difference is usually made in the contract price. On one sale where the sawyers cut off the limbs, lopped the tops, and scattered the brush the contract was $1.25 per thousand for timber running about fifteen and one-half logs. Efficient crews of two men cut about 5000 feet daily, while others cut as low as 4000 feet.

On another sale where the fallers worked singly at felling and bucking, the contract price was $1.75 per thousand including the swamping work. Each man averaged from 2000 to 2500 feet daily. Another logger in the same region paid $2 per thousand for the same work.

Swamping is usually done by a member of the skidding crew, one man being assigned to each team. Since the Forest Service requires that the brush shall be scattered or piled the swamping expense is increased. The cost of brush disposal on small operations depends largely on the species, the depth of snow, the amount of dead material and young growth, the steepness of the slopes and the character of the bottom. Timber with many limbs such as Engelmann spruce and lodgepole pine necessitate more cutting and handling than most other species, hence brush disposal is more expensive. Snow from 18 to 24 inches deep makes brush disposal disagreeable, and seriously hampers the work. Where dead material is found among young growth the piles must be made where reproduction will not be injured during brush burning and where down timber will not be ignited. Men are hampered in getting around on steep slopes and rough ground and hence brush disposal is more costly. As a rule, brush piling and scattering on small operations, if properly done, each cost from 30 to 50 cents per thousand feet. Sawyers sometimes do the swamping and piling during the summer and fall for an advance of from 25 to 30 cents per thousand.

Skidding. — The movement of the logs from the stump to the mill is performed either in one or two operations. On good bottom and short hauls the logs are either skidded directly to the mill or else hauled on sleds or carts over inexpensive roads.

About 500 board feet constitutes a load under the latter condition. The choice of methods depends on the season of the year. In rough sections and for distances greater than $\frac{1}{4}$-mile the logs are usually yarded to skidways and then hauled on wagons or sleds to the mill. On rough and steep places a single horse is used for skidding, while on favorable bottoms two horses are employed.

On one operation yarding with one horse to a skidway not more than 200 feet distant costs about 75 cents per thousand with an additional sled haul charge of $1.49 per thousand for distances up to $\frac{3}{4}$-mile. On another operation where single teams were used with carts in summer and sleds in winter, the cost of haul was $3 per thousand for a maximum distance of $\frac{7}{8}$-mile and an average haul of $\frac{1}{2}$-mile. On an operation which yarded its logs to skidways and hauled on sleds for an average distance of $\frac{1}{4}$-mile, the cost of logging was as follows:

	Cost per 1000 board feet.
Felling and bucking	$1.00
Brush disposal	.25
Swamping	.28
Skidding	.72
Logging roads	.07
Hauling	1.42
Camp depreciation	.10
Total	$3.84

The men were boarded in a camp run by the company. The rate was 75 cents per day with free bunk house privileges, the laborers furnishing their own bedding.

On another operation where the skidding distance averaged 150 feet and the average haul was three-eighths of a mile, the contract price delivered at the mill was $5 per thousand, as follows:

	Cost per 1000 board feet.
Felling, bucking, swamping and brush disposal	$2.00
Yarding and hauling	3.00
Total	$5.00

B. NORTHEAST

Period of Logging. — Operations are usually confined to a period of from twenty-six to thirty-two weeks, beginning in the late summer and closing during the early spring. Where railroad transport is used summer logging is practiced.

Labor. — The labor is composed chiefly of French Canadians and Europeans. The men are generally employed by the month and are furnished board and lodging. The average camp crew consists of about sixty men.

Camps. — The buildings usually are log structures which house from fifty to sixty men, and from twenty-five to forty horses. Camps are used for two or three seasons and then abandoned or else used as storehouses. Board camps are used chiefly on railroad operations. Supplies are hauled in on sleds or wagons where rail transport is not available. Workmen do not bring their families into camp.

Topography and Bottom. — The topography of the region ranges from rolling to rough, and the bottom is often covered with a heavy growth of underbrush. The steep slopes are usually rocky. The rolling land provides a good bottom for animals. Swamps are common in the region and usually have to be logged during the winter season.

Felling and Log-making. — The practice is to fell the timber with the saw and ax. The boles are cut into standard lengths for saw logs, and into long logs when the timber is to be manufactured into pulpwood, although occasionally pulpwood timber is cut into 4-foot lengths for ease in handling. The fallers work in crews of two or three men and cut and make into logs from 5000 to 8000 feet of timber, daily. Spruce pulpwood is sometimes peeled in the forest.

Skidding. — Animal logging predominates in the region, although a few cableway skidders have been used in New England on difficult logging chances. Snaking machines have been employed to a very limited extent in the mountains of northern New York. Yarding, on operations where a sled haul is used, begins early in September and continues until the snow gets too

deep for profitable felling, which is usually during the latter part of December. Logs are decked on skidways along two-sled roads and are either dragged to the yard by a single animal or a team, or else hauled on a yarding sled. A skidding and a felling crew of seven men can cut and skid from 5000 to 7000 feet daily on a $\frac{1}{2}$-mile haul when a team and yarding sled are employed for moving the timber.

Chutes and log slides are occasionally employed on some operations to bring logs down steep slopes.

Transportation. — Logs are usually transported from the skidways to a landing on a stream on a two-sled drawn by two or four horses, or on a yarding sled when the haul does not exceed $\frac{1}{2}$-mile. Steam log haulers are frequently substituted for animal draft on long hauls. The logs are floated out of the small streams during the early spring freshets and are driven down the large streams during the summer.

Railroad operations are not common, but where rail transport is used logs are yarded and hauled on sleds to the railroad during the winter months, and yarded directly to the railroad during the summer.

Flumes have been used in a few instances for bringing pulpwood from the forest to a stream down which it is driven.

The common form of transporting logs to the mill is by floating. Rafting is practiced only after the logs are sorted on the lower stretches of the stream. Drives are conducted largely by incorporated companies.

COST OF OPERATION

	Cost per 1000 board feet.
General camp expense	\$ .90 to \$ .90
Toting supplies	.15 to .15
Road making	.30 to .40
Yarding	2.00 to 2.50
Hauling	1.00 to 1.50
Camp construction	.06 to .10
Water transport	1.00 to 2.00
Total	\$5.41 to \$7.55

C. LAKE STATES — WHITE PINE

Period of Logging. — Railroad operations are conducted throughout the year unless suspended on account of snow. When logs are transported on sleds to streams down which they are driven, the season is from thirty to thirty-six weeks long, beginning in the late summer and ending with the termination of hauling.

Labor. — The laborers are chiefly Swedes, Norwegians, Finns, Austrians and Poles. Foremen are often native-born Americans. The wage basis of payment is common.

Camps. — On railroad operations camps are often board structures although log buildings are also used. The latter are employed almost exclusively on operations where the logs are hauled on sleds and floated down streams. Workmen are boarded and housed by the operator.

Topography and Bottom. — The topography varies throughout the region. In some sections the land is flat, more often it is rolling and "pot holes," which present difficult logging problems, are common. The brush is often dense in the forest where the pine is mixed with hardwoods, while in pure stands of pine the undergrowth is usually scanty.

Felling and Log-making. — This work is performed by a crew of two or three men who operate under the direction of a saw boss. Low stumps are cut and the bole is taken to a top diameter of about 4 inches. Logs are generally cut into standard lengths. The daily output of a crew of two men is from 6000 to 10,000 feet, log scale, depending on the size of the timber.

Skidding. — Animal logging is predominant. Several methods are used for bringing logs to the skidway which is either along a railroad or a sled road. For small logs and for distances of from 300 to 400 feet snaking is common while for large logs and rough bottom go-devils are employed. Logs are snaked for 500 or 600 feet on snow bottom. High-wheeled carts are used by some operators for logging to a railroad in summer, when hauling for distances from $\frac{1}{4}$- to $\frac{1}{2}$-mile. In winter logging, swamps are crossed and often hauls of $\frac{1}{2}$-mile are made by

means of a jumbo dray, the logs being snaked out to the roads and then hauled directly to the skidway along the railroad. Steel-spar cableway skidders (p. 197) are now used on some hardwood and hemlock operations.

Transportation. — Railroads are the chief form of transport. During the spring, summer and fall the logs required daily are yarded directly to the railroad and loaded on cars. The winter supply of logs is either decked along the railroad or else yarded at more remote spots and then hauled to the railroad on two-sleds. There are only minor interruptions of railroad traffic due to snowfall. The use of two-sleds for hauling logs to a stream down which they are floated is less common than formerly, because of the high value of the white pine stumpage and the large amounts of heavy hardwoods which are now being logged.

Steam log haulers (p. 172) are common in the Lake States on sled hauls, sometimes bringing the logs directly to the mill.

Cost of Logging. — The following costs were those incurred on a white pine operation during 1909. The railroad haul was 14 miles, 7 on a logging road and 7 on a trunk line. The logs were snaked to the railroad, loaded with a crosshaul, and hauled at once to the mill. The daily output of the camp was from 200,000 to 210,000 feet, log scale.

	Cost per 1000 board feet.
Felling	\$ .38 to \$ .45
Skidding and swamping	1.00 to 1.50
Loading	.20 to .25
Railroad construction	.60 to .75
Railroad operation	.45 to .50
Total	\$2.63 \$3.45

D. SOUTHERN YELLOW PINE

Period of Logging. — The year round.

Labor. — White and colored. The former provide the more skilled labor and the latter the unskilled, although colored laborers occasionally occupy positions of responsibility. On

some operations in the northern part of the region, whites are employed exclusively.

Camps. — They are composed chiefly of portable houses in which the loggers and their families reside. A general store, church and school house are usually provided. Car camps may be used when families are not furnished accommodations.

Topography and Bottom. — In the southern part of the region the country is flat or rolling, while on the northern edge it is usually broken. The bottom in the longleaf forests is generally free from brush, while in the loblolly and shortleaf forests there is often a heavy undergrowth.

Felling and Log-making. — This is customarily done by a two-man crew which uses a saw and an ax. The daily output is from 7500 to 15,000 feet, depending on the size of the timber and the stand per acre. Contract work prevails. Where animal skidding is used logs are cut in standard lengths, while where power skidding is employed they are cut in lengths ranging from 24 feet up to the entire merchantable bole. Sometimes only the tops are cut from the trees and the bole is brought to the mill and there cut into logs.

Skidding. — Animal logging predominates throughout the region, although the snaking system (p. 204) is common in the flat pineries, and occasionally a cableway skidder (p. 196) is used. So far as is known the slack-rope system is not employed. The favorite method of animal logging is to "snake" the timber for short distances, and to move distant logs with bummers, high carts or wagons. When standard length logs are handled bummers are a favorite vehicle for the shorter distances, and 4-, 6-, or 8-wheeled wagons for long distances. High wheeled carts are preferred for long logs, and are often employed for short logs on hauls of 800 feet or less.

Transport. — The almost universal form of long-distance transport of logs from the forest to the mill is by railroad, because of the continuous operation of the plant, lack of suitable streams for driving and the weight of the timber. Where streams are available, floating is practiced to a very limited extent by some

of the smaller operators; however, the loss from sunken timber is from 25 to 33 per cent.

Cost of Logging. — The following table shows the cost of animal logging, during 1911, on a flat bottom where the stand averaged from 10,000 to 12,000 feet per acre. The railroad haul for two-thirds of the output did not exceed 6 miles, and for the remainder was about 20 miles.

	Cost per 1000 board feet.	
Logging:		
Cutting	$0.445	
Swamping	.062	
Hauling	.590	
Feed	.205	
Spur construction	.605	
Fuel	.055	
Loading on cars	.346	
Repairs (locomotives and cars)	.133	
Main-line expense	.136	
General expense	.359	$2.936
Manufacture:		
Sawmill	$1.395	
Dry houses and yards	1.122	
Log pond	.074	
Sales expense	.485	
Planing mill	.833	
Trucking and loading	.690	
Discount	.172	
Sundries	2.139	$6.910
Total cost, exclusive of stumpage		$9.846

The average sale value of the product f.o.b. mill was $15.30.

On another operation where the stand averaged 5100 feet per acre, the topography was rolling, the main-line railroad haul was 10 miles and the logs were moved on wagons, the cost for the year 1909 was as follows:

	Cost per 1000 board feet.	
Logging:		
Cutting and hauling	$1.892	
Loading on cars	.189	
Railroad construction and operation	1.131	$3.212
Manufacture:		
Sawmill	1.564	
Drying, stacking and hauling	1.025	
Depreciation on stock (6 per cent)	.566	
Planing and shipping	1.164	
Sundry expenses, insurance, etc	1.067	5.386
Total cost, exclusive of stumpage		$8.598

The average sale value f.o.b. mill was $13.03.

E. CYPRESS

Period of Logging. — The year round.

Labor. — The unskilled labor is composed of negroes, creoles and Mexicans, and the skilled labor of whites. Contract work prevails.

Camps. — Floating camps built on scows are used on pullboat operations, and permanent board camps on railroad operations.

Character of Bottom. — The bottom on many of the swamps is covered with water during a portion of the year, although there are many "islands" and other extensive areas which are seldom, if ever, submerged, where railroad camps may be located. The timber grows both on the wet ground and on the higher elevations. The bottom is too soft for animal logging.

Felling and Log-making. — The timber, which is girdled or deadened some weeks or months in advance of felling and log-making, is felled and made into logs with the ax and saw. Workmen are paid by the log, tree or thousand feet cut. A crew of two men will fell and make into logs from 7500 to 10,000 feet of timber, daily. Timber is cut to a minimum diameter of 8 inches in the top.

Skidding. — Three methods are employed.

(1) *Hand Logging.* — During low water the timber is deadened and later felled. Creeks or lanes from 50 to 150 feet wide are cut through the forest with reference to the current during flood time. When the swamp is covered with from 5 to 6 feet of water the logs are "poled" out to the creeks down which they are floated to a rafting station, where they are rafted and towed to the mill.

(2) *Pullboat Logging.* — A slack-rope skidding device (page 208) is mounted on a scow and moored in a canal, bayou or lake to which logs are dragged for distances of from 3500 to 5000 feet. They are then rafted and towed to the mill. The daily output is from fifty to seventy-five logs.

(3) *Cableway Skidding and Rail Transport.* — A cableway skidder (p. 196) is placed alongside a spur or main-line track and logs are yarded to the railroad from distances of from 600 to

800 feet. They are then loaded on cars and transported to the mill. The daily output is from 30,000 to 40,000 feet per skidder.

Transport. — Floating and railroading are the two methods employed.

(1) *Floating.* — The logs are made into cigar-shaped units about 125 feet long and several of them are joined together into a raft and towed to a mill.

(2) *Railroad.* — Main lines are usually built on piling. Spur roads, which are located approximately $\frac{1}{4}$-mile apart are "dunnage" roads (p. 283). Light-weight engines and skeleton cars are employed. Logs are loaded on cars by a special device on the skidder.

COST OF OPERATION

	Cost per 1000 board feet.
Pullboat operation:	
Deadening	\$0.08 to \$0.12
Felling and log-making	.50 to .50
Sniping	.16 to .16
Road cutting	1.25 to 2.50
Pullboating	1.25 to 1.60
Rafting	.06 to .06
Superintendence	.10 to .12
Towing	.50 to 1.00
General expense	.25 to .25
Total cost	\$4.15 \$6.31
Railroad operation:	
Deadening	\$0.11 to \$0.11
Felling and log-making	.50 to .50
Skidding and loading	1.00 to 1.20
Spur construction	.50 to .60
Main-line construction	.20 to .30
Operating charge (railroad)	.50 to .60
Skidder repairs	.13 to .18
General expense and superintendence	.50 to .70
Total	\$3.44 \$4.19

F. NORTHWEST

Period of Logging. — The year round.

Labor. — Logging is highly specialized and requires a large number of skilled men among whom are found natives, Swedes and Norwegians. Unskilled labor is foreign and consists of the

two nationalities mentioned and, in addition, men from southern Europe.

Camps. — Either car camps, board camps or portable houses are used to shelter the men. Families seldom reside in camp. Laborers are housed and boarded by the logger.

Topography and Bottom. — The region ranges from rolling to rugged and in many sections difficult logging problems are encountered. Underbrush is heavy in the coast forests where rainfall is abundant.

Felling and Log-making. — Felling and log-making are done by separate crews. Fallers who work in crews of two may or may not do the notching. Two log buckers who work alone are required for each crew of fallers. Logs are cut in even lengths of 24 feet or more.

Yarding. — Power logging is now almost universal, the slack-rope system (p. 208) being the predominant form. A few cableway skidders (p. 196) are in operation and are gaining in popularity for handling small and medium-sized timber.

Animal logging is found only on small operations where the "chance" is favorable and the output limited.

Transport. (1) *Road Engine.* — A road engine sometimes takes logs from the yarding engine to a stream or railroad (p. 218). This practice is less common than formerly.

(2) *Locomotive.* — A geared locomotive may be employed to drag the logs over the crossties to a landing along the railroad (p. 220).

(3) *Railroad.* — The most desirable practice is to place the yarding engines along the logging railroad. Logs are loaded on flat or skeleton cars or log trucks and hauled to the mill, to a driveable stream, or to tide-water. When yarding engines are employed cars are loaded with jacks or with a gin-pole, and when the cableway skidder is used the logs are loaded with a special device provided for that purpose. Cars are unloaded by hand methods, log dumps, or other special unloading devices.

(4) *Rafting.* — Logs are usually rafted and are seldom floated singly to the mill.

(5) *Flumes.* — These are occasionally employed for bringing logs from the forest to the railroad or some stream.

(6) *Chutes.* — Chutes and slides are in frequent use in some sections for bringing logs down steep slopes and for handling logs on bottom that cuts up badly in dry weather. Three-pole and five-pole chutes are in most common use (p. 233).

(7) *Aerial Tramways.* — These are employed to bring logs from high elevations to lower ones, especially on very rough ground.

Cost of Logging. — The average daily output and the cost per thousand feet for yarders operating 900 feet of line are given below.[1] The costs refer only to the yarding work and are based on a labor expense of $26 per day and a per diem allowance of $10 for upkeep of machinery, blocks, rigging, lines and other equipment.

Average log content.	Amount yarded daily.	Cost per 1000 board feet for yarding.
Board feet.	Board feet.	
2000	90,000	$0.40
1750	78,750	.45
1500	67,500	.53
1250	62,500	.59
1000	55,000	.65
750	41,250	.87
500	32,500	1.12
250	22,500	1.60

A road engine operating for 3000 feet can handle the output of two yarding engines. The crew consists of five men, namely, one engineer, one fireman, one wood-buck, one grab-setter and one chaser. When a road engine handles the output of two yarding crews the cost per thousand feet is approximately as follows, allowing $32.50 per day for labor, deterioration of machinery and road upkeep.

[1] See the American Lumberman, Chicago, Illinois, September 24, 1910, p. 46.

Average log content.	Cost per 1000 board feet for hauling.
Board feet.	
2000	$0.18
1750	.21
1500	.25
1250	.26
1000	.30
750	.40
500	.50
250	.70

If only one machine is yarding to the road engine the cost will be approximately 85 per cent higher.

The total cost of logging on an average Douglas fir operation is approximately as follows:

	Cost per 1000 feet.
Felling and bucking	$0.55
Yarding and loading	1.00
Railroad transportation (logging road)	.35
Railroad transportation (trunk line)	1.50
Booming	.25
Scaling	.05
Sales expense for logs	.05
Repairs, renewals, maintenance, insurance	.75
Railroad construction	.50
Depreciation	.20
Supervision, city office expense, miscellaneous	.25
Total	$5.45

G. MOUNTAIN LOGGING IN WEST VIRGINIA [1]

Period of Logging. — The year round.

Labor. — The foremen are usually Americans, and the remaining laborers are chiefly foreigners, such as Italians, Austrians, Poles and Hungarians with a small percentage of other nationalities.

Camps. — The camps are chiefly board structures built along the logging railroad. They accommodate from fifty to seventy-five men and from twenty-five to thirty-five horses. Board and lodging are provided by the operator. Families seldom reside in camp.

[1] See Cost of Mountain Logging in West Virginia, by Henry H. Farquhar. Forestry Quarterly, Vol. VII, pp. 255–269.

Topography and Bottom. — The region in which extensive operations are now conducted is rugged with narrow valleys and steep slopes, covered in many places with massive boulders that are a hinderance to logging. Mountain laurel is abundant throughout the forest and necessitates heavy swamping.

Felling and Log-making. — On operations where hemlock bark and logs are utilized the bark peelers fell, bark and cut the boles into logs during the months of May to August, inclusive. During the remainder of the year the felling crews, consisting of a chopper and two sawyers, go through the forest felling and cutting into logs the remaining spruce and hemlock trees. The hardwoods are cut after the softwoods to avoid the loss through breakage that would occur if all of the timber were felled at one time. Trees are cut to a stump diameter of 10 inches and the boles to a top diameter of 8 inches for saw logs, and 4 inches for pulpwood. A crew of two men will fell and make into logs from 15,000 to 20,000 feet of spruce and hemlock, daily. Two knot cutters are often members of the felling crew. Their duty is to snipe the ends of the logs and to remove the limbs from them.

Skidding. — Skidding is done largely with animals. Roads or trails are cut from the valleys up to the tops of the ridges and the logs are dragged down in tows either over skipper roads or pole slides. A team on a skipper road will handle from 5000 to 6000 feet daily on a haul of $\frac{1}{4}$-mile. Slides (p. 230) are common in some sections and are built from a few hundred feet to a mile or more in length.

The cableway system of power logging is in occasional use, and on some operations single-line snaking machines are employed for dragging logs for distances as great as 2500 feet.

Transportation. — On many operations the logs are hauled to the mill on narrow- or standard-gauge railroads. The narrow-gauge roads are frequently of the stringer type. The railroad is usually built up the main "draws" or valleys. Spurs are seldom constructed because of the heavy expense.

Inclines are common and occasionally aerial trams are employed.

Logs are loaded both by hand and with power loaders of several types.

Water transport is used in regions where suitable streams are available. The logs are hauled to the stream and placed in the channel awaiting a freshet to carry them down stream.

Cost of Logging. — The cost of contract logging on an operation in the mountainous parts of West Virginia with a twenty-mile railroad haul is as follows:

	Cost per 1000 board feet.
Felling	$0.95
Road-making and swamping	.87
Skidding	1.76
Loading	.35
Office expense	.08
General expense	.24
Railroad construction	.86
Total	$5.11

The total cost of lumber f.o.b. car at the mill for the year 1909 was as follows:

	Cost per 1000 feet.
Logging, including stumpage	$8.46
Milling	1.64
Log train service	1.67
Office expense	.15
General expense, taxes, legal fees, etc	.03
Total	$11.95

H. ALASKA[1]

Period of Logging. — Chiefly during the warmer months.

Logging Methods. — Until recently hand logging has been the common method along the shores, but this is now being replaced by the slack-rope system of power logging. The donkeys are

[1] Hoffman, Bruce E.: Sitka Spruce of Alaska. Proceedings of the Society of American Foresters, Vol. VII, No. 2, pp. 226–238.

mounted on scows which are towed to the point where logging is to be carried on. Loggers seldom operate more than 900 feet from shore, although in one case a road engine and a donkey were employed and the logs brought from a maximum distance of 2500 feet. Timber is becoming scarce that can be reached by present methods and improved machinery will soon be required.

Cost of Operation. — The average cost of operating with power logging on the Tongass National Forest is about as follows:

	Cost per 1000 board feet.	
Felling	$0.75	
Lopping tops	.02	
Yarding to booming place	2.00	
Booming	.25	$3.02[1]
Towing	.75	
Boom cost (bucking and placing on mill deck)	.20	
Sawing	1.875	
Edging	.375	
Trimming	.75	
Yard cost	1.00	
Planer, cost on finished material	1.50	
Loading and selling	1.00	
Fuel and oil	.50	
Upkeep	.50	
Manufacturing license	.10	
Stumpage	1.00	9.55
Total cost		$12.57

[1] Logs are usually sold in the market at about $5 per thousand feet, hence on most operations the cost of logs to the millman is $1.98 additional.

The average percentage of each grade sawed from Sitka spruce is as follows:

	Per cent.
Clear	15
No. 1 common	20
No. 2 common	15
Box	20
Dimension	20
Cull	5

The average retail prices are as follows:

	Value per 1000 board feet.
Rough lumber, mill run	$15.00
½-sized, mill run	16.00
Ship-lap, mill run	17.50
Select (finish)	20.00
Finish, clear	30.00

PART VI

MINOR INDUSTRIES

CHAPTER XXV

TURPENTINE ORCHARDING

The production of naval stores was an important industry in some of the South Atlantic States, especially in the Carolinas where the industry flourished for many years, but it has been on the decline since 1880, the year of maximum production.

Florida is now the center of the industry, producing more than one-half of all the turpentine and rosin output of this country. Other States in which large quantities are produced are Texas, Louisiana, Alabama, Mississippi, Georgia and South Carolina.

The production in 1911 was 638,000 casks of turpentine and 3,916,000 barrels[1] of rosin.[2] The greater part of these products find their market in Europe.

Species Worked. — All coniferous trees contain resinous materials in their wood, but resin ducts are best developed in the hard pines of the South which furnish the raw material from which naval stores are secured.

The product obtained by "bleeding" a pine tree is known as gum, crude turpentine or resin. From this, turpentine, rosin and pitch are secured by distillation. Pitch pine (*Pinus rigida*) yields limited quantities of crude turpentine. It was worked successfully in the East during the Revolutionary war but the industry has ceased to exist because of the scarcity of timber and the limited yield per tree.

Shortleaf pine (*P. echinata*) does not yield resin readily and the face of the tree dries rapidly. Although the yield per tree is limited, the so-called "Rosemary" pine, a form of shortleaf, is bled when found in the vicinity of other species that are being worked.

[1] 280 pounds each.

[2] Naval Stores Review, Savannah, Georgia, June 27, 1912, p. 40.

Loblolly pine (*P. tæda*) contains a large amount of resinous material in its sapwood similar in composition to that found in longleaf. The crude turpentine from this species is more fluid in character, dries faster on the face of the cut, and the yield per tree is limited so that this species is not regarded with favor in longleaf regions. However, it has been and still is extensively worked in the Carolinas.

Cuban pine (*P. heterophylla*) which occurs largely in the State of Florida is worked with the longleaf. It bleeds for a longer period than other species and produces only a small amount of scrape.

Longleaf pine (*P. palustris*) is the tree most productive of crude turpentine and furnishes the raw material from which the bulk of the world supply of turpentine and rosin are produced.

Attitude of Lumbermen toward Turpentine Orcharding. — All owners of stumpage are not agreed as to whether it is profitable to bleed pine timber for naval stores because of the increased fire risk, liability to wind damage especially on boxed timber, the depreciated value of the butt log which is the best portion of the tree,[1] the increased weight of bled timber which averages about 200 pounds per thousand feet heavier than unbled timber and the loss of killed timber which ranges from 1 per cent on cupped trees to 5 per cent on boxed timber.

Stumpage from bled timber is held at from 50 to 65 per cent less than that of unbled. Where timber is now bled, logging follows soon after the cessation of orcharding. Turpentining is not as prevalent among operators on the west side of the Mississippi River as on the east side, although the practice appears to be growing as the methods of orcharding are improved.

Large stumpage owners and lumber operators as a rule prefer to run their own turpentine operations rather than to lease the rights to others. Where leases are made, safeguards are provided in the contract which strictly define the rights and responsibilities of the lessee. The lease may be made on the

[1] Some operators claim that the loss in quality and quantity is fully 20 per cent.

basis of the crop or the acre, and usually runs for a three- or four-year period.

The average lease price per acre is from $2.50 to $4.50 for a four-year period, while the rental per crop for the same time ranges from $700 to $1000. A stipulation is frequently placed in the contract requiring the turpentine operator to pay for all timber killed during his lease. The price for this is based on the stumpage value of the timber and is estimated annually at the close of the season.

METHODS OF OPERATION

For many years crude turpentine was harvested in a primitive and wasteful manner by means of the box method, but within the last ten years the box is rapidly being replaced by cups or other receptacles which are less injurious to the tree, and which yield a higher percentage of turpentine and a better grade of rosin.

A. THE WORKING UNIT

A pine forest, called a turpentine orchard, is divided up into working units, called crops. These are composed of 10,500 boxes or cups which cover an area of from 200 to 250 acres in the virgin longleaf forests, and an area of from 500 to 1600 acres in the Carolina fields which are largely exhausted. Crops are further divided into five "drifts," comprising 2100 boxes each. On large operations from ten to fifteen crops are in charge of a woodsman or woodsrider who is responsible to a superintendent in charge of the entire operation. The boundaries of crops and drifts are usually marked by blazes to guide the laborers.

The development of a new crop begins early in the fall, by firing the forest and burning off the grass, fallen needles and other refuse on the forest floor, which would prove a menace to the timber after the trees have been prepared for bleeding.

Following the burning of the litter comes the preparation of the receptacle for catching the gum as it comes from the tree. This is done during the period between October and March, when labor is abundant and is not required on other parts of the operation.

B. THE SIZE OF TREE AND THE NUMBER OF RECEPTACLES

Trees as small as 6 inches in diameter are often bled, although it is seldom profitable to work trees under 12 inches.

The number of boxes or cups placed on a tree is governed chiefly by its size; small trees having one receptacle, medium-sized trees, from 18 to 24 inches in diameter, two, and those of greater diameter from two to four. During the last year the crop is worked some operators "back box" the timber, that is, they place additional cups on the trees.

It is essential that a strip of cambium from 3 to 6 inches wide be left between each scar in order that the tree will not be girdled, and die during the first season.

When the turpentine rights only are leased, the timber often is bled more heavily than where the work is done by the owner of the timber.

C. THE BOX SYSTEM

Cutting the Boxes. — The box consists of a wedge-shaped incision cut into the base of the tree at a height of from 8 to 12 inches above the surface of the ground.

The size of the box depends on the diameter of the tree, but usually the opening is from 6 to 7 inches in height, from 9 to 14 inches wide and the base slopes downward at an angle of 35 degrees for a distance of 7 inches. The capacity of these boxes varies from 1 to 3 quarts.

Boxing is done with a long-bitted, straight-handled ax of special pattern. The negro laborers who work by contract are paid from $1\frac{1}{2}$ to 2 cents per box. On large operations the men work in crews of from forty to fifty in charge of a foreman, who inspects and tallies the boxes cut by each man. A water boy is a necessary member of the crew and is usually paid by the laborers, each one of whom contributes two boxes per day toward the payment of his wage.

A good box cutter will average from 80 to 150 boxes per day. Some are able to cut 200 per day, but not all of the boxes will be well made.

Cornering. — Boxing is followed by cornering, performed by two workers, one right-handed, the other left-handed. An ordinary ax is used for this purpose. From the peak of the box a slanting cut one inch deep is made upward until its outer edge is directly above the outer edge of the box. A side blow then splits out the wood between the cut and the outer edge of the tree. The object of cornering is to provide a suitable face for the commencement of the subsequent scarification of the tree.

Two men can cut 2000 faces per day. The contract price ranges between $1.25 and $1.50 per thousand faces.

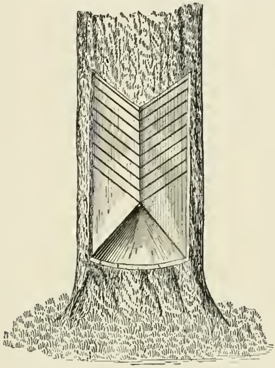

FIG. 129. — A Turpentine Box for the collection of Crude Turpentine.

Chipping. — In tapping a tree very little resin is actually secured from the resin ducts already in the wood. The main flow is from secondary ducts which arise as a consequence of the injury due to chipping.[1] Resin begins to flow about February 15 or March 1 and chipping or scarification then begins. This consists in laying bare the surface of the sapwood directly above

[1] See The Origin and Development of Resin Canals in the Coniferæ with Special Reference to the Development of Tyloses and their co-relation with the Thylosal Strands of the Pteridophytes, by Simon Kirsch. Proc. Royal Society of Canada, 1911. Also Relation of Light Chipping to the Commercial Yield of Naval Stores, by Charles H. Herty. Bulletin No. 90, U. S. Forest Service, Washington, 1911.

the box, the incision being made about $\frac{3}{4}$-inch deep and from 1 to 2 inches wide. The tool used for this purpose is called a hack and consists of a blade of high-grade steel about 3 inches wide bent into a U-shape. The cutting blade is fastened by a shank and band to a 2-inch handle, from 18 to 24 inches long, on the end of which is attached a 6-pound iron weight to give force to the stroke. A patent hack recently placed on the market can be adjusted to cut any thickness of chip desired, and in addition makes a square cut instead of a concave one.

The chipper or renter, as he is called, stands squarely in front of the box and by a right-hand and left-hand stroke removes the chip from the face of the tree. The freshly cut surfaces, called streaks, meet just above the center of the box, forming the peak, and extend upward at an angle of about 40 degrees to a line perpendicular to the outer edge of the box. The cut must not penetrate the heartwood, or else the face becomes "dry" and resin ceases to run. The flow from the fresh incisions runs over the scarified face into the box below. It is most vigorous on the first day after chipping and gradually diminishes until the seventh day, when it practically ceases. It is necessary, therefore, to "chip" the trees weekly, approximately thirty-two streaks being made during the first season. Each successive streak increases the distance to the box, and at the end of the first season the scarified face has extended from 18 to 20 inches up the tree; the second year the distance is from 36 to 42 inches; the third year from 60 to 65 inches; and the fourth year from 80 to 85 inches.

Recent experiments have shown that a thin streak produces as good results as a thick one, and has the additional advantage that the tree is easier to chip, since the streaks do not advance up the tree to so great a height.

The practice of running the chipped faces spirally up the tree has been advocated in order to extend the length of time that a tree could be worked readily. Such a plan is not impracticable since the movement of sap is from one cell to another, through pits in the side walls and not straight up and down the tree. This practice however, is not general.

It is seldom profitable to operate trees for a period greater than four years because of the reduced yield and the inferior grade of the product.

Turpentine operators distinguish the different aged faces as follows:

First year	"Virgin"
Second year	"Yearlings"
Third year	"3-year-old"
Fourth year	"Bucks" or "pulling boxes"

During the latter part of the third year and the fourth year the height of the streak above ground becomes too great for the chipper to use the short-handled "hack" and a tool called the puller is substituted. This consists of a steel blade, similar to that on the hack, mounted on the end of a pole about 5 feet long. This tool is used in the same manner as a hack.

One man can chip from 2000 to 2400 boxes daily, and during a week will attend one crop. The laborer is paid from 75 to 80 cents per thousand boxes.

Dipping. — Resin is allowed to accumulate in the box for about four weeks when the "dip," as it is called, is collected. This is done eight or nine times during the first year and gradually diminishes during the following seasons until the fourth year when three or four dips only are made. Empty barrels are distributed by wagon at suitable intervals throughout the crop and a laborer with a large 8- or 10-gallon wooden bucket dips the crude turpentine from the boxes, using a flat, oval dipper attached to a handle about $3\frac{1}{2}$ feet long.

The flow is most abundant during the months of July and August, and gradually diminishes as the season advances. In virgin boxes it ceases during the latter part of October. Each year the season becomes shorter. Dipping of "yearlings" closes usually during September, and 3-year-old and bucks during the latter part of August, or the first days of September.

The average dip per crop during a season is as follows:

Virgin crop	250 to 300 barrels [1]
Yearling crop	185 barrels
3-year-old crop	125 barrels
Buck crop	125 barrels

[1] Capacity, 51 gallons.

One man can dip from three to four barrels per day, and can tend from 6000 to 10,000 boxes. He is paid from 50 to 65 cents per barrel.

After a crop has been dipped, the barrels are hauled to the still on a wagon drawn by two mules. A pair of skids are attached to the rear end of the wagon and allowed to drag as it proceeds through the orchard. Barrels usually have a patent rim, so that a tight head may be readily placed in them in order that the barrels may be turned on edge and rolled up the skids. A wagon will haul six or eight barrels at one time.

Scraping. — The crude turpentine flowing over the face of the wound, especially during the third and fourth years, when the distance is greatest, thickens and loses some of its volatile oil, both by evaporation and oxidation and forms over the surface a thick coating known as scrape. This is collected after the last dip of the season has been made. A "scraper" attached to a long handle is used to free the scrape from the scarified face.

The average amount of scrape secured each season is as follows:

Virgin crop	50 to 70 barrels[1]
Yearling crop	100 to 120 barrels
3-year-old crop	100 to 140 barrels
Buck crop	100 to 140 barrels

Scrape gatherers receive from 10 to 15 cents per 100 pounds for collecting scrape, or 40 cents for 325 pounds net (one barrel). One man can collect from 1200 to 1500 pounds daily. Scrape is collected in barrels in the same manner as dip.

Raking. — Following the collection of scrape, steps are taken to protect boxed timber against fire. Men, women and boys with heavy hoes remove all grass, pine needles and other débris from the base of the tree, making a clear circular space with a radius of 2 or 3 feet. The average day's work is from 400 to 700 trees. The contract price ranges from 20 to 35 cents per 100 trees, or from $12 to $15 per crop.

[1] Capacity, 51 gallons.

D. CUP SYSTEMS

The wastefulness of the box system early led to a search for a better method. The first effort in this country to devise a new receptacle was made in 1869 by a South Carolina operator, whose invention, however, did not prove successful. A Louisiana operator put out a cup in 1895, but it proved too expensive to place on the trees, and was, therefore, abandoned. During the last fifteen years numerous other devices have been brought out but only a few of them have proved of value.

HERTY'S CUP AND GUTTER

About ten years ago a "cup-and-gutter" system was patented[1] and has since proven so practical that it has been widely adopted. An earthen or galvanized iron pot[2] or cup into which the resin is conveyed by means of galvanized iron gutters[3] is hung on the face of the tree. The cup and gutters are advanced up the tree at the beginning of each season, so that the distance between the streak and cup is always short. This lessens the evaporation of volatile oils and reduces the amount of scrape. The gum also does not absorb as much coloring matter in passing over the scarified face, and, therefore, produces a higher grade of rosin.

Hanging the Cups. — The work of hanging cups begins early in the season, usually in February or early March. The organization of the crew is different from that used in cutting boxes because of the variety of work to be performed. On some operations a laborer armed with a hack precedes the crew and cuts two diagonal streaks on the tree, which meet at a point directly over the center of the face. Face cutters then follow and,. with an 8- or 9-pound broadax, cut two opposite flat faces 10 or 12 inches high and from 6 to 10 inches wide that meet at

[1] Dr. Charles H. Herty, patentee.

[2] The clay pots are 7 inches high; top diameter $5\frac{1}{2}$ inches; bottom diameter 3 inches; capacity from 1 to $1\frac{1}{2}$ quarts. The galvanized iron pots are of approximately the same capacity.

[3] The gutters are made of strips 2 inches wide, bent lengthwise along the center at an angle of 120 degrees.

an angle directly under the apex of the streak. On some operations the faces are cut sometime in advance of the streak. This practice is partly responsible for the criticism that has been made of the cup-and-gutter system since it requires from two to three more chippings to produce the first dip of the season than for the box system. The reason for this is that the upper portion of the two flat faces have oval outlines, and the resin ducts are formed along the upper edges of the faces. The first chipping is made from each side to the center, and only those ducts along the center of the face are opened. On the other

Fig. 130. — A Workman cutting Incisions on the Face of the Tree, into which Gutters are to be inserted. Herty's system.

hand, when boxes are used "cornering" makes a straight face, and all ducts along the line of the cut are opened up by the first streak.

The faces provide a flat surface for the gutters and for hanging the cups. Their cost is less than box corners because they are not cut so deep. A 12-inch broadax is then used to cut incisions for the insertion of the gutters which slant at an angle of about 40 degrees. One incision is made on each face, the upper one being about 3 inches below the chipping face and the lower one on the opposite side about 1 inch lower.

A galvanized gutter is then inserted into each incision, the lower gutter projecting about $1\frac{1}{2}$ inches past the upper one so that it forms a spout to carry off the resin from both gutters. A 6-penny zinc nail is then driven on the face opposite the lower gutter and in such position that the gum will drain into a cup hung on it. Wire nails were formerly used for hanging cups but they were difficult to pull from a pitchy face and laborers often left them in the tree, which damaged the saws at the mill when the timber was sawed into lumber. Zinc nails are soft enough to be cut by a band saw without injury.

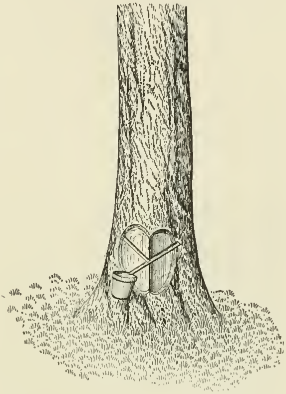

Fig. 131.—A Tree equipped with a Herty Cup and Gutters. The first streaks will be cut at the upper edge of each face.

Cups are hung by crews following the gutter placers. At the end of the season cups are removed from the nails and turned upside down by the tree, since they break if water accumulates and freezes in them.

The placement of cups and gutters is done largely by day labor. On an Alabama operation the crew for placing Herty cups and gutters was composed of eighteen men whose duties were as follows:

2 men cutting streaks	1 man distributing gutters
4 men cutting faces	6 men placing gutters
2 men cutting incisions for gutters	1 man distributing cups
	2 men driving nails and hanging cups

This crew averaged about 2500 cups per day, and the average cost per crop for labor was $100.

The second and following seasons only ten men were required to hang the same number of cups, because the streak and face cutters and the gutter and can distributors were not needed.

The cost of installing a crop of this character as estimated by the inventor [1] is as follows:

Cups (10,500 at $1\frac{1}{4}$ cents)	$131.25
Gutter stripping (1,886 pounds of galvanized iron, 29 gauge, cut in 2-inch widths)	103.27
Nails (6-penny wire nails)[2]	1.05
Freight charges (estimated)[3]	30.00
Labor at tree	80.00
Cutting and shaping gutters	4.00
Total	$349.57

The cost of cutting and cornering boxes is from $250 to $300.

Chipping. — The chipping and pulling of a crop of cups is performed in the same manner as for boxes.

FIG. 132. — A Herty Cup on a "Yearling" Crop. The cup was raised at the beginning of the second season.

Dipping. — The dip is collected in barrels, but the form of receptacle on the tree requires some modification of the box method for dipping. The dipper passes from tree to tree with his bucket, lifts the cups from the nail and by means of a trowel-shaped paddle scoops the gum out of the cup, which is then replaced on the tree. When a tree bleeds freely extra cups are kept hanging on nails, and when the chipper passes on his rounds he replaces full cups with empty ones, hanging the former on nails on the lower part of the tree. By this means no resin is lost. The same price per barrel is paid for dipping both cups and boxes.

[1] A New Method of Turpentine Orcharding, by Chas. H. Herty. Bul. 40, U. S. Bureau of Forestry, p. 31.

[2] Zinc nails have since been substituted.

[3] Shipping weight approximately 25,000 pounds.

The handling of the crop from this time on is very similar to a crop of boxes.

Advantages of the System. — Not only is the yield of turpentine increased by the use of cups, but the grade of rosin is higher and under average conditions may be worth annually $150 more per crop than that secured from boxes. The danger from fire is also reduced, because the scarified faces do not take fire as readily as the resinous matter in boxes.

THE McKOY CUP

The McKoy cup is attached to the tree by means of a galvanized-iron apron instead of a nail. The box is rectangular in

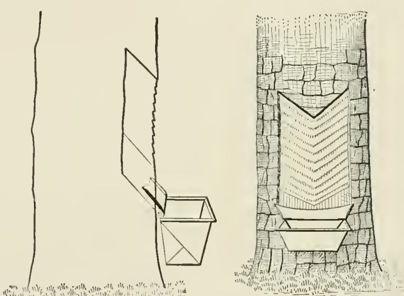

FIG. 133. — The McKoy Cup, used for the collection of Crude Turpentine.

form, and of the following dimensions: length 12 inches, width $3\frac{1}{4}$ inches and depth $3\frac{1}{2}$ inches. The capacity is approximately two quarts. They are made from one piece of sheet iron folded together into the form of a box. The apron has one concave edge so that it will fit the bole of the tree. The back edge of the box is turned forward and down forming a flange by which it is attached to another flange on the outer edge of the apron.

The tools required for hanging cups consist of a special concave-edge broadax and a wooden maul. Cups and aprons are distributed throughout the orchard to all trees that are to be

bled. Two men then follow, one using the broadax and the other a maul. A face about 8 inches long and 6 inches wide is cut on the bole just deep enough to expose the wood. This removes loose bark and facilitates the hanging of the cup. A gash is then cut into the face by holding the broadax, head down, against the tree at a sharp angle and striking it two or three times with the maul. The concave face of the apron is inserted and gently driven in this incision, the wood closing over it and holding the apron firmly in position. The cup is then hung on the apron and the crop is ready to turn over to the chipper.

It is claimed that two experienced men can place about 1000 cups per day, and the same number of inexperienced hands 500 per day.

THE GILMER-McCALL CUP

This cup is a radical departure from any heretofore placed on the market. It consists of a circular glass bowl 7 inches long and 3 inches in diameter, to the top of which is screwed a galvanized cap.

This system is designed to do away with the scarification of the bole of the tree, and at the same time prevent the evaporation of volatile oils and the accumulation of dirt common in the old-style cups and boxes.

Two $\frac{3}{4}$-inch holes are bored by a power- or hand-driven auger up through the sap at an angle of about 45 degrees. These holes start from a common point on the tree and their length varies with the diameter of the tree, for they must not break through the sapwood nor enter the heartwood. The average length is about 5 inches. A circular hole is then reamed in the bark around the two openings and the cap of the cup inserted into it and fastened to the tree by brads. When the holes become clogged they are reamed out. This system has not proved a success.

The lease cost of the cups complete f.o.b. is 10 cents per cup the first year, and 2 cents per cup each succeeding year. A power-driven boring machine with tools complete is listed at $150.

DISTILLATION OF CRUDE TURPENTINE

The process of distillation requires experience and care on the part of the operator to secure the highest yields of turpentine and the best grades of rosin.

The apparatus consists of a large copper retort, holding from ten to thirty barrels,[1] a condensing tank, a coil and a straining trough. The bottom of the retort is slightly arched in the center to facilitate the withdrawal of the rosin through a large gate valve. A detachable neck fits over a narrow mouth on top of the retort and conveys the volatile matter to the condenser from which the oil and water are carried by gravity to a barrel. The base of the retort is about 5 feet above ground, which allows for the placement of a grate underneath and also permits the withdrawal of the rosin from the retort by gravity. The retort is inclosed on all sides by brick and has a stack on one side to carry off the smoke from the fire.

The strainers through which the hot rosin is passed are three in number, and are 30 inches wide, from 12 to 16 feet long and 12 inches deep and are made so they will nest. The top one has a $\frac{1}{4}$-inch mesh screen to catch the bark and other coarse refuse; the second a $\frac{1}{8}$-inch mesh; and the third a very fine copper mesh over which a layer of cotton batten is placed. The latter removes sediment that was not strained out previously.

Retorts are often of 25-barrel capacity, and including the copper neck weigh about 1000 pounds. They cost approximately $750.

The following are the usual charges for a retort of the above size:

Virgin dip	12 barrels
Yearling dip	10 barrels
3-year-old dip	10 barrels
Buck	8 barrels
Scrape	8 barrels

The older the face from which resin is secured the more it boils up on heating, hence the retort charges for old dip are less

[1] A standard barrel for crude turpentine holds 280 pounds — about one-half the size of a 52-gallon barrel.

than for virgin. The retort is filled from the top. After removing the neck, the dip is poured in from barrels until the required amount is secured. The fire is then started under the retort and the mass slowly heated. If the dip is virgin the bark as it rises to the surface is skimmed off in order to improve the grade of rosin, for bark discolors it. Skimming is usually dispensed with for dip of other ages. The neck is now placed on the retort and connected with the condenser and then securely fastened to the retort by lugs. All joints between the neck and retort are sealed with wet clay. The mass is then gradually brought to the boiling point. Turpentine and water early begin to pass over into the condenser and then by gravity run to a storage barrel on the ground floor. Turpentine which has a lower specific gravity than water readily separates from it and is run off from the top of the barrel into the barrel in which it is shipped to market. About the middle of the process a small stream of warm water is admitted to the retort from the condensing tank and it is allowed to run until the process is completed, which is indicated by a peculiar noise of the boiling contents of the still, and also by the diminished quantity of oil in the distillate. Great care must be taken toward the end of the process not to burn the rosin. The process being complete the fire is put out and the rosin is drawn off at the gate valve, and conducted by a trough into the strainer tubs.

Scrape is handled in the same manner as dip, with the exception that a barrel of water is added at the start to prevent burning.

It requires from three to four hours to run a charge of crude turpentine. Three men are usually employed on a large plant, namely, a still tender, a helper and a cooper, who manufactures rosin barrels.

Turpentine is put up in 51-gallon double-glued oak barrels and as soon as it has cooled it is tightly corked and held ready for market. Rosin barrels are crude affairs made of rough pine boards, and are put together at the still. Cracks are chinked up with clay. The usual capacity is from 500 to 560 pounds.

As soon as the rosin has cooled somewhat in the straining vat,

it is dipped into the barrels and allowed to become thoroughly hard, which takes about twenty-four hours. It is then ready for shipment.

Rosin is separated into fourteen grades, the basis of which is color. The best grade "W.W.," known as "water white," is very transparent and clear, while the lowest grade "A" is black in color.

The annual yield per crop of turpentine and rosin varies with the number of years the trees have been bled. The average yields are as follows:

	Turpentine.	Rosin.	Grades of rosin.
	Gallons.	Barrels.	
Virgin dip	2000–2100	260	Higher and highest grades
Yearling dip	2000	175	I. H. & G.
3-year-old dip	1100	100	F. E. D.
Bucks	800	100	C. B. A.

The above figures were secured at a plant where the output of boxes and cups was distilled together.

During the last two years a crop is worked under the cup system, the yield of turpentine and rosin is somewhat greater and the grade of rosin higher than shown in the above table.

The usual yield from five barrels of dip is one barrel of spirits of turpentine and three barrels of rosin; and from ten barrels of "scrape," one barrel of spirits of turpentine and three and one-third barrels of rosin.

Cost of a Distillation Plant. — The estimated cost of establishing a turpentine orcharding plant and of working the crop for four years is approximately $2700 where twenty or more crops are managed together. The cost of equipment alone, for twenty crops of boxed timber, including the still, houses, sheds, tools, wagons and mules is about $6000.

MARKETS

Savannah is the chief market for naval stores but Jacksonville, Florida; Charleston, South Carolina; Wilmington, North Carolina; and New Orleans, Louisiana are also important centers.

The products are chiefly sold on commission. The market price of turpentine and rosin fluctuates greatly due to market manipulation and to unfavorable weather conditions which influence production.

Turpentine was quoted on the Savannah market on February 24, 1913 at $42\frac{1}{2}$ cents per gallon. The highest market price on record was \$1.07 per gallon obtained on March 25, 1911; and the lowest, 22 cents per gallon obtained on September 4, 1896. The best grade of rosin "W.W." in the above market averaged from \$7.25 to \$7.80 per barrel during the month of January, 1913, while "B" grade brought from \$4.95 to \$5.60.

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CHAPTER XXVI

HARVESTING TANBARK

The barks of the hemlock and of several species of oak were for years the main source of the tannin supply of the United States, but the growing scarcity of these species has led to the introduction of various substitutes, among them quebracho wood extract from South America and chestnut wood extract. The eastern hemlock (*Tsuga canadensis*) furnishes the only coniferous tanbark in the East. The western hemlock (*T. heterophylla*) of the Pacific Coast, which is now used only to a limited extent, will be in demand in the future, because of the high percentage of tannin it contains. The chief eastern oak whose bark is used for tanning is the chestnut oak (*Quercus prinus*). In the West the bark of the tanbark oak (*Q. densiflora*) is extensively harvested for this purpose. Various black and white oaks are used to a limited extent.

The average per cents of tannin contained in the barks of different species are as follows:[1]

Species.	Per cent.
Eastern hemlock	13.11
Western hemlock	15.1
Tanbark oak	16.46
Chestnut oak	6.25
Spanish oak	8.59
Black oak	5.90
White oak	5.99
Red oak	4.56

HEMLOCK

The peeling of bark can be carried on only during the growing season. It begins from the first to the middle of May and lasts

[1] Report on the Forests of North America (exclusive of Mexico), by Charles S. Sargent. Vol. IX, Tenth Census. Washington, D. C., 1884, p. 265.

until the latter part of July or the first of August, after which time the bark sticks and cannot be removed profitably. The best months are June and July. A crew is commonly composed of four men, namely, one fitter, one spudder, and two log cutters. The fitter selects the trees to be felled, then with an ax cuts a ring through the bark around the base of the tree. He then cuts another ring 4 feet above the first, and splits the bark down one side of the tree from ring to ring. The spudder then inserts a tool known as a spud between the bark and wood and peels off the bark.

The tree is next felled by the log cutters, after which the fitter girdles the bole in 4-foot sections and cuts a line through the bark along the entire length. He also swamps off the limbs that will interfere with the work of the sawyers or spudder. The latter then removes the bark on these sections, peeling it in as large pieces as is possible, to reduce future handling, and leans it, bark side out, against the fallen log to dry. This takes from several days to a month, depending on the weather. The log cutters now cut up the bole.

On some operations two men compose a crew, and do both the felling and bark peeling. The timber then is not cut into logs until later in the season when the regular logging operation begins.

If the dry bark is not removed from the forest until snow falls, it is piled in ricks, bark side up, to prevent the tannin from leaching out during rainy weather. Often, as soon as dry, it is hauled on wagons or crude sleds to the railroad. Frequently it is transported to the base of steep mountain slopes in triangular or rectangular troughs, made in portable sections. The workmen start near the base of the slope, sending down all bark within a short radius of the chute. As the work progresses up the slope new sections are added to the trough until the upper edge of the cutting is reached. The slide is then removed and the process repeated on a new route. On very steep pitches the speed of the bark is checked by a board, one end of which is hinged to a support above the slide with the other end resting in the trough. The bark in passing raises the board and the

friction produced checks its speed. This method breaks up the bark and is used only when necessary.

The preferable form of transport where the ground is not too steep for horses is to load the bark on a sled or dray holding two to two and one-half cords and drag it to the loading dock along the railroad. A common form of sled consists of two 15-foot birch poles with the rear ends dragging and the front ends fastened to a short sled. A bunk built on the rear of the runner carries a roller used in tightening the binding rope on the load. Another form consists of a sled with ironwood runners 12 feet long, turned up at both ends, so that the sled may be dragged in either direction. The sled is equipped with stakes to hold the bark, and also with rollers to aid in tightening the binding ropes.

Both forms of sleds are pulled either with one or two horses. One man with a team will haul daily from eight to ten cords, and with one horse, from five to six cords.

Output. — A crew of two men will fell the timber and peel from three to four cords per day. This does not include making the tree into logs. Four men will peel from five to eight cords daily and cut the timber into logs. A crew of the latter size can peel about 250 cords in a season.

		Cost per cord.[1]
Peeling		$2.00
Hauling:		
1 teamster	$2.00 per day	
1 teamster, board	.60 per day	
2 horses, labor at	2.00 per day	
2 horses, board at	1.00 per day	
	$5.60 per day for 9 cords.	.62
Loading:[2]		
7 men at $1.70 per day	$11.90	
7 men, board at $.60 per day	4.20	
	$16.10 for 25 cords.	.65
Total		$3.27

[1] 2240 pounds.

[2] Seven men loaded 4 cars daily, each car having a capacity of from 6 to 7 cords, depending on the care in stowing exercised by the men.

Bark peeling and handling is frequently done by contract, the jobber receiving from \$3.50 to \$4.50 per cord on the car. The contract price on board car on a West Virginia operation, 1909, was \$4 per cord. The contractor's expense is given on page 461.

The yield of bark varies with the size of the trees and the region in which the timber grows and is usually calculated on the basis of the amount of timber cut. Pennsylvania operators expect to secure one cord from 1500 to 2000 feet, log scale; New York operators, one cord from 1700 to 2000 feet, log scale; Michigan operators, one cord from 2000 feet, log scale; while in Maine and West Virginia the yield is one cord from 2000 to 2500 feet, log scale.

The following data on the yield and thickness of bark on trees of given diameter, and the weight of hemlock bark per square foot, were secured in the Adirondack region of New York:

YIELD OF HEMLOCK BARK[1]

Diameter of tree at stump.	Yield of bark.	Diameter of tree at stump.	Yield of bark.
Inches.	In cords.[2]	Inches.	In cords.
9	0.020	20	0.163
10	0.026	21	0.189
11	0.036	22	0.210
12	0.045	23	0.240
13	0.056	24	0.275
14	0.065	25	0.305
15	0.078	26	0.340
16	0.091	27	0.370
17	0.106	28	0.405
18	0.121	29	0.440
19	0.141	30	0.480

[1] From the Fourth Annual Report of the Forest Preserve Board, 1900. Albany, N. Y., 1901 pp. 84–86.

[2] 2240 pounds.

THICKNESS OF BARK

Diameter of tree outside bark.	Thickness of bark.	Diameter of tree outside bark.	Thickness of bark.
Inches.	Inches.	Inches.	Inches.
7	$\frac{1}{4}$	17	$\frac{15}{16}$
8	$\frac{3}{8}$	18	1
9	$\frac{15}{32}$	19	$1\frac{1}{16}$
10	$\frac{17}{32}$	20	$1\frac{3}{32}$
11	$\frac{19}{32}$	21	$1\frac{1}{8}$
12	$\frac{21}{32}$	22	$1\frac{5}{32}$
13	$\frac{23}{32}$	23	$1\frac{5}{32}$
14	$\frac{25}{32}$	24	$1\frac{3}{16}$
15	$\frac{27}{32}$	25	$1\frac{7}{32}$
16	$\frac{29}{32}$		

WEIGHT OF HEMLOCK BARK PER SQUARE FOOT

Thickness of bark.	Weight per square foot.	Thickness of bark.	Weight per square foot.
Inches.	Pounds.	Inches.	Pounds.
$\frac{3}{8}$	1.00	$1\frac{1}{4}$	2.85
$\frac{1}{2}$	1.25	$1\frac{3}{8}$	3.10
$\frac{5}{8}$	1.63	$1\frac{1}{2}$	3.32
$\frac{3}{4}$	1.90	$1\frac{5}{8}$	3.54
$\frac{7}{8}$	2.15	$1\frac{3}{4}$	3.72
1	2.40	$1\frac{7}{8}$	3.92
$1\frac{1}{8}$	2.62	2	4.12

Bark is shipped to tanneries and stored in sheds or in the open in well constructed piles in order to prevent the bark from becoming moist, otherwise it becomes moldy and the tannin leaches out. As tannin is more readily extracted from dry bark than from green it is usually seasoned for a year or more.

CHESTNUT OAK

Peeling operations are conducted from the middle of April until the middle of June or the first of July. The general plan of peeling and hauling bark is the same as for hemlock. Many small operations are conducted and the bark sold f.o.b. car by the owner to tannery agents. The ruling price in Virginia and West Virginia during the summer of 1911 was $8.50 per cord on the car.

The average cost per cord of harvesting chestnut oak bark in the Appalachians is as follows:[1]

Cutting, peeling, and curing, per cord	$1.25–1.50
Carrying and sledding, per cord	.90–1.45
Sleds and sledding roads, per cord	.15– .30
Total	$2.30–3.25

Tanbark from the headwaters of the Potomac river in West Virginia in 1911 was delivered at Edinburg, Virginia, 16 miles distant, at approximately the following cost per cord:

Stumpage $0.50 to	0.75
Cutting, peeling, and bringing to the wagon road	1.50
Wagon haul, 16 miles	4.00
Loading on car	0.35
Total	$6.60

[1] From Logging, Lumbering, or Forest Utilization, by C. A. Schenck.

The average value per cord, f.o.b. car, was $8.

The approximate yield of bark is one cord from 1500 feet, log scale, Doyle rule. The yield from individual trees in the Appalachian region is as follows:

YIELD OF BARK IN RELATION TO DIAMETER OF TREE[1]

Diameter, breast high.	Yield of bark.	Diameter, breast high.	Yield of bark.
Inches.	Cords.	Inches.	Cords.[2]
10	0.06	21	0.17
11	0.06	22	0.19
12	0.07	23	0.20
13	0.08	24	0.22
14	0.09	25	0.24
15	0.10	26	0.26
16	0.11	27	0.28
17	0.12	28	0.30
18	0.13	29	0.32
19	0.15	30	0.34
20	0.16		

[1] From Chestnut Oak in the Appalachians. Circular 135, U. S. Forest Service, p. 11.
[2] 2240 pounds.

TANBARK OAK

The tanbark oak is a native of southwestern Oregon and of California, where the harvesting of tanbark has been an important industry for many years. The peeling season begins about May 20 and lasts until the middle of August, although it can be done best during the latter part of the season for the bark is then tougher and does not break readily.

There is a variation in the length of the peeling season, because the trees are very sensitive to changes in temperature. Individual trees also show a decided difference in their peeling qualities.

Peelers work in pairs and use only a single-bitted ax. The tree is first girdled at 4 feet above ground, again at the ground, and the bark then slit and pried off with an ax. The tree is then felled and the bark ringed and peeled off in the same manner as in hemlock. The work is continued up the bole until the bark becomes less than ½ inch in thickness. The "coils" of bark are laid on the ground, bark side down, and allowed

to dry and curl up. Trees from 3 inches and up in diameter are also peeled. It is customary to cut one or two coils from standing poles from 3 to 8 inches in diameter. This is called "jayhawking" and is very wasteful because the yield per tree is low and good bark which cannot be reached is often left on the upper portion of the tree. On other trees the bark is removed up to the large limbs only. An average workman will peel from one to one and one-half cords of bark daily, and an expert on big timber may occasionally peel four or five cords.

In three weeks the bark is dry enough to haul. It is then bunched by hand in small piles to which narrow sled roads are cut, and down these the bark is sledded to wagon roads and again piled. It is then hauled to market or railroad on wagons which carry from three to four cords each. In rough places the bark is sometimes transported to the roads on mules. From 250 to 400 pounds of bark are loaded on a pack saddle and carried by one animal. After the bark has been hauled to the wagon roads, men are sent through the forest to collect and sack the chips. These come chiefly from the base of the tree and are richer in tannin than the bark from any other part of the bole.

The average yield of bark is from one and one-fourth to two cords per acre, with a maximum of eight cords.

AMOUNT OF TANBARK ON TANBARK OAK TREES OF DIFFERENT SIZES[1]

Diameter.	Height.	Length of peeled trunk.	Weight of bark.	Dry weight of bark (calculated).
Inches.	Feet.	Feet.	Pounds.	Pounds.
4–9	30–50	4–8	15–80	10–70
10–12	40–80	16–32	80–350	70–250
13–18	80–100	32–65	350–900	250–650
19–24	90–120	65–80	900–1700	650–1200
24–36	115–140	80–95	1700–2500	1200–1800
36–48	100–120	80–90	2500–4000	1800–2800
48–60	100–120	80–90	3500–8000	2500–5700

[1] From the California Tan Bark Oak, by Willis Linn Jepson and H. S. Betts. Bulletin 75, U. S. Forest Service, p. 10.

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Barrel and Box. Chicago, Illinois. Monthly, $1.50. (Cooperage and box trade.)

Canada Lumberman and Woodworker. Toronto, Ontario, Canada. Monthly, $2. (General.)

Hardwood Record. Chicago. Semi-monthly, $2. (Hardwood trade.)

Lumber Trade Journal. New Orleans, La. Semi-monthly, $2. (Southern lumber trade.)

Lumber World Review. Chicago. Semi-monthly, $2. (General.)

New York Lumber Trade Journal. New York. Semi-monthly, $2. (Eastern lumber trade.)

Paper Trade Journal. New York. Weekly, $4. (Paper and pulp trade.)

Pioneer Western Lumberman. San Francisco, California. Semi-monthly, $2. (Pacific Coast lumber interests, especially in California.)

St. Louis Lumberman. St. Louis, Missouri. Semi-monthly, $2. (General, although chiefly devoted to yellow pine interests.)

Southern Industrial and Lumber Review. Houston, Texas. Monthly, $1. (Southwestern lumber interests.)

Southern Lumber Journal. Wilmington, North Carolina. Monthly, $3. (Atlantic Coast lumber interests.)

Southern Lumberman. Nashville, Tennessee. Weekly, $4. (General, although devoted largely to the hardwood interests.)

The Timberman. Portland, Oregon. Monthly, $2. (Pacific Coast interests, chiefly logging.)

West Coast Lumberman. Tacoma, Washington. Monthly, $1. (West Coast lumber interests.)

Western Lumberman. Toronto, Ontario, Canada. Monthly, $2. (Canadian lumber interests.)

Wood Craft. Cleveland, Ohio. Monthly, $1. (Wood-working industries.)

Wood Worker. Indianapolis, Indiana. Monthly, $1. (Wood-working industries.)

TERMS USED IN LOGGING

TERMS USED IN LOGGING[1]

[Letters in parentheses following definitions indicate the forest regions (see Fig. 1) in which the terms as defined are used.

(Gen.) = General = In all forest regions of the United States.
(C. H. F.) = Central Hardwood Forest.
(N. F.) = Northern Forest.
(App.) = Appalachian Forest.
(L. S.) = Lake States Forest.
(N. W.) = North Woods.
(S. F.) = Southern Forest.
(R. M. F.) = Rocky Mountain Forest.
(P. C. F.) = Pacific Coast Forest.

In a few instances very local terms are ascribed to a State instead of to a forest region.]

Alder grab. The stem of an alder, or other small tree, which is bent over and plugged into a hole bored in a boom stick, or secured in some other way, to hold a boom or logs inshore. (N. F.)

Alligator, *n.* 1. A boat used in handling floating logs. It can be moved overland from one body of water to another by its own power, usually applied through drum and cable. (N. W., L. S.)

2. A device, often made from the fork of a tree, on which the front end of a log is placed to facilitate skidding on swampy ground. (S. F.)

Anchor line. A line attached to a small buoy and to one fluke of an anchor used in towing a raft of logs. It is employed to free the anchor when fast to rocks or snags. (N. F.)

Apron, *n.* 1. A platform projecting downstream from the sluiceway of a dam to launch well into the stream logs which pass through the sluiceway. (Gen.)

2. A platform built of timbers at the foot of a slide, which guides in the desired direction logs leaving the slide. (Gen.)

Ark, *n.* *See* Wanigan.

Back line. *See* Haul back.

Ballhooter, *n.* One who rolls logs down a hillside. (App.)

Bank, *v.* *See* Bank up, to.

Bank, *n.* 1. *See* Landing.

2. The logs cut or skidded in one day above the required amount and held over by the saw crew or skidders, to be reported when the required daily number is not reached. (N. F.)

[1] From Terms Used in Forestry and Logging, Bul. 61, U. S. Bureau of Forestry, Washington, 1905.

Banking ground. *See* Landing.

Bank up, to. To pile up logs on a landing. (Gen.)
Syn.: bank.

Barker, *n.* One who peels bark in gathering tanbark. (Gen.)
Syn.: peeler, spudder.

Barking iron. *See* Spud.

Bark mark. A symbol chopped into the side of a log to indicate its ownership; when used with the end mark it serves as an additional means of identification. (Gen.) *See* Mark.
Syn.: side mark. (N. F.)

Bark marker. One who cuts the bark mark on logs. (Gen.)

Barn boss. One who has charge of the stables in a logging camp. (Gen.)
Syn.: feeder. (N. W.)

Batten, *n.* A log less than 11 inches in diameter at the small end. (Maine.)

Battery, *n.* Two or more donkey engines for dragging logs, set at intervals on a long skid road. (P. C. F.)

Beaver, *n.* *See* Swamper.

Becket, *n.* A large hook used in loading logs on cars by means of tackle. (P. C. F.)

Bed a tree, to. To level up the path in which a tree is to fall, so that it may not be shattered. (P. C. F.)

Bicycle, *n.* A traveling block, used on a cable in steam skidding. (S. F.)

Bigness scale. *See* Full scale.

Big Wheels. *See* Logging wheels.

Binder, *n.* A springy pole used to tighten a binding chain. (Gen.)
Syn.: jim binder.

Binding chain. A chain used to bind together a load of logs. (Gen.)
Syn.: wrapper chain. (N. F.)

Binding Logs. Logs placed on the top of the chain binding a load, in order to take up the slack. (Gen.)

Birl, *v.* To cause a floating log to rotate rapidly by treading upon it. (Gen.)

Bitch chain. A short, heavy chain with hook and ring, used to fasten the lower end of a gin pole to a sled or car when loading logs. (N. F.)

Blaze, *v.* To mark, by cutting into trees, the course of a boundary, road, trail or the like. (Gen.)
Syn.: spot. (N. W.)

Block, *n.* *See* Brail.

Blow down. *See* Windfall.

Blue jay. *See* Road monkey.

Bluing, *n.* The result of fungus attack, which turns the sapwood of certain trees blue. (Gen.)

Bob, *n.* *See* Dray.

Bobber, *n.* *See* Deadhead.

Bob logs, to. To transport logs on a bob or dray. (N. F.)

Body wood. Cord wood cut from those portions of the stem of trees which are clear of branches. (N. F.)

Bolster, *n.* *See* Bunk.

Boom, *n.* Logs or timbers fastened together end to end and used to hold floating logs. The term sometimes includes the logs inclosed, as a boom of logs. (Gen.)

Boomage, *n.* Toll for use of a boom. (Gen.)

Boom buoy. *See* Boom stay.

Boom chain. A short chain which fastens boom sticks end to end. (Gen.)

Boom company. A corporation engaged in handling floating logs, and owning booms and booming privileges. (N. F.)

Boom pin. A wooden plug used to fasten to boom sticks the chain, rope, or withe which holds them together. (Gen.)

Boom rat. One who works on a boom. (N. F.)

Boom stay. A heavy weight used to anchor booms in deep water; its position is indicated by a pole or float attached to it. (N. F.)

Syn.: boom buoy.

Boom stick. A timber which forms part of a boom. (Gen.)

Bottle butted. *See* Swell butted.

Bottom sill. *See* Mudsill.

Brail, *v.* To fasten logs in brails.

Brail, *n.* A section of a log raft, six of which make an average tow. (L. S.)

Syn.: block. (S. F.)

Brake sled. A logging sled so constructed that, when the pole team holds back, a heavy iron on the side of each runner of the forward sled is forced into the roadbed. (N. F.)

Brand, *n.* *See* Mark.

Break out, to. 1. To start a sled whose runners are frozen to the ground. (N. W., L. S.)

2. To open a logging road after heavy snowfall. (N. W., L. S.)

Breastwork log. *See* Fender skid.

Briar, *n.* A crosscut saw. (Gen.)

Bridle, *n.* A device for controlling the speed of logs on a skid road. It consists of a short rope with two hooks at one end, which are driven into the first log of the turn; at the other end is a clamp which runs over the cable. (P. C. F.)

Bridle man. One who follows a turn of logs down the skid road and tends the "bridle." (P. C. F.)

Broadleaf, *a.* *See* Hardwood.

Brow skid. The chief beam in a frame to which tackle for loading logs on cars is fastened. (P. C. F.)

Syn.: draw skid, lead log.

Brush a road, to. To cover with brush the mudholes and swampy places in a logging road, to make it solid. (N. F.)

Brush snow fence. A snowbreak to protect a logging road; used most commonly on wide marshes. It consists of brush which is set upright in the ground before it freezes. (N. F.)

Brutting crew. A crew which rolls logs down slopes too steep for teams. (App.)

Buck, *v.* 1. To saw felled trees into logs. (P. C. F.)

2. To bring or carry, as to buck water or wood. (Gen.)

Bucker, *n.* 1. One who saws felled trees into logs. (P. C. F.)

Syn.: cross cutter.

2. One who brings or carries. *See* Buck.

Buckwheat, *v.* *See* Hang up, to.

Buckwheater, *n.* A novice at lumbering. (Gen.)

Bull chain. 1. A very heavy chain, to which a number of short chains, with hooks on one end and dogs on the other, are attached. It is used to draw logs from the mill pond up the gangway. (Gen.)

2. *See* Jack chain.

Bull cook. *See* Chore boy.

Bull donkey. A large donkey engine which, by drum and cable, drags logs from the place where they are yarded to a landing. (P. C. F.)

Bully, *n.* A common name for the foreman or boss of a logging camp. (N. F.)

Bummer, *n.* A small truck with two low wheels and a long pole, used in skidding logs. (N. F., S. F.)

Syn.: drag cart, skidder.

Bunch load, to. To encircle several logs with a chain and load them at once, by steam or horse power. (N. F.)

Bunch logs, to. To collect logs in one place for loading. (Gen.)

Bunk, *v.* To place upon the bunks, as to "bunk a log." (Gen.)

Bunk, *n.* 1. The heavy timber upon which the logs rest on a logging sled. (N. F.)

Syn.: bolster.

2. The cross beam on a log car or truck, on which the logs rest. (Gen.)

3. A log car or truck. (S. F., P. C. F.)

Bunk chain. *See* Toggle chain.

Bunk hook. The hook attached to the end of the bunk on a logging car, which may be raised to hold the logs in place or lowered to release them. (Gen.)

Bunk load. A load of logs not over one log deep; *i.e.*, in which every log rests on the bunks. (Gen.)

Bunk spikes. Sharp spikes set upright in the bunks of a logging sled to hold the logs in place. (N. F.)

Bush a road, to. To mark the route of a logging road across a marsh or the ice by setting up bushes. (N. F.)

Butt, *n.* The base of a tree, or the big end of a log. (Gen.)

Butt cut. 1. The first log above the stump. (Gen.)
Syn.: butt log. (Gen.)
2. In gathering tanbark, the section of bark taken from the butt of a tree before felling it for further peeling. (N. F.)

Butt hook. The hook by which the cable is attached to the tackle on the logs. (P. C. F.)

Butt log. *See* Butt cut.

Butt off, to. 1. To cut a piece from the end of a log on account of a defect. (Gen.)
Syn.: long butt, to. (P. C. F., App.)
2. To square the end of a log. (N. F.)

Buttress, *n.* A wall or abutment built along a stream to prevent the logs in a drive from cutting the bank or jamming. (Gen.)

Butt team. In a logging team of four or more, the pair nearest the load. (Gen.)

Camp inspector. A lazy lumberjack, who goes from one logging camp to another, working only a short time in each. (N. F.)

Cannon a log, to. In loading logs by steam or horse power, to send up a log so that it swings crosswise, instead of parallel to the load. (N. F.)

Cant dog. *See* Cant hook.

Cant hook. A tool like a peavey, but having a toe ring and lip at the end instead of a pike. *See* Peavey. (Gen.)
Syn.: cant dog.

Cap, *n.* A cone of sheet iron or steel, with a hole in the end through which a chain passes, which is fitted over the end of a log before snaking it, to prevent catching on stumps, roots or other obstacles, in steam skidding. (S. F.)

Catamaran, *n.* A small raft carrying a windlass and grapple, used to recover sunken logs. (Gen.)
Syn.: sinker boat (Gen.), monitor, pontoon (P. C. F.)

Catch boom. A boom fastened across stream to catch and hold floating logs. (Gen.)

Catface, *n.* A partly healed over fire scar on the stem of a tree. (P. C. F.)

Catpiece, *n.* A small stick in which holes are made at regular intervals, placed on the top of uprights firmly set in floating booms. The uprights are fitted to enter the holes in the catpiece, so as to narrow or widen the space between the booms at the entrance to a sluiceway or sorting jack. The catpiece is held by the uprights high enough above water to allow logs to float freely under it. (N. W., L. S.)

Cattyman, *n.* An expert river driver. (N. F.)

Center jam. A jam formed on an obstacle in the middle of a stream, and which does not reach either shore. (Gen.)
Syn.: stream jam.

Chain grapples. *See* Grapples.

Chain tender. *See* Sled tender.

Check, *n.* A longitudinal crack in timber caused by too rapid seasoning. (Gen.)

Syn.: season check.

Cheese block. *See* Chock block.

Chock block. A small wedge or block used to prevent a log from rolling. (Gen.)

Syn.: cheese block. (P. C. F.)

Choker, *n.* A noose of wire rope by which a log is dragged. (P. C. F.)

Choker man. The member of a yarding crew who fastens the choker on the logs. (P. C. F.)

Chopper, *n.* *See* Faller.

Chore boy. One who cleans up the sleeping quarters and stable in a logging camp, cuts firewood, builds fires and carries water. (Gen.)

Syn.: bull cook, flunkey, shanty boss.

Chunk, *v.* To clear the ground, with engine or horses, of obstructions which cannot be removed by hand. (P. C. F.)

Chunk up, to. To collect and pile for burning the slash left after logging. (N. W., L. S.)

Churn butted. *See* Swell butted.

Chute, *n.* *See* Slide.

Coal off, to. To cut a forest clean for charcoal wood. (N. F.)

Commissary, *n.* A general store for supplying lumbermen. (App., S. F.) *See* Van.

Conk, *n.* 1. The decay in the wood of trees caused by a fungus. (N. F., P. C. F.)

2. The visible fruiting organ of a tree fungus. (N. F., P. C. F.)

Conky, *a.* Affected by conk. (N. F., P. C. F.)

Cook camp. The building used as kitchen and dining room in a logging camp. (Gen.)

Syn.: cook house, cook shanty.

Cookee, *n.* Assistant cook and dishwasher in a logging camp. (Gen.)

Cook house. *See* Cook camp.

Cook shanty. *See* Cook camp.

Corkscrew, *n.* A geared logging locomotive. (P. C. F.)

Syn.: stem-winder. (App.)

Corner binds. Four stout chains, used on logging sleds, to bind the two outside logs of the lower tier to the bunks, and thus give a firm bottom to the load. (N. F.)

Corner man. In building a camp or barn of logs, one who notches the logs so that they will fit closely and make a square corner. (N. F.)

Coupling grab. *See* Grapples.

Crab, *n.* A small raft bearing a windlass and anchor, used to move log rafts upstream or across a lake. (N. F., S. F.)

Cradle, *n.* A framework of timbers in which ocean-going rafts of logs are built. (P. C. F.)

Cradle knolls. Small knolls which require grading in the construction of logging roads. (N. W., L. S.)

Crazy chain. The short chain used to hold up that tongue of a sprinkler sled which is not in use. (N. F.)

Crib, *n.* Specifically, a raft of logs; loosely applied to a boom of logs. (N. F.)

Crib logs, to. To surround floating logs with a boom and draw them by a windlass on a raft (a *crab*), or to tow them with a steamboat. (N. W., L. S.)

Cross chains. Chains connecting the front and rear sleds of a logging sled. (N. F.)

Cross cutter. *See* Bucker.

Cross haul. The cleared space in which a team moves in cross hauling. (N. F.)

Cross haul, to. To load cars or sleds with logs by horse power and crotch or loading chain. (Gen.)

Crotch, *v.* To cut notches on opposite sides of a log near the end, into which dogs are fastened. (P. C. F.)

Crotch, *n.* *See* Dray.

Crotch chain. A tackle for loading logs on sleds, cars or skidways by cross hauling. (Gen.)

Crotch tongue. Two pieces of wood, in the form of a V, joining the front and rear sleds of a logging sled. (N. W., L. S.)

Cruise, *v.* To estimate the amount and value of standing timber. (Gen.)
Syn.: estimate, value.

Cruiser, *n.* One who cruises. (Gen.)
Syn.: estimator, land looker, valuer.

Cull, *n.* Logs which are rejected, or parts of logs deducted in measurement on account of defects. (Gen.)

Cut, *n.* A season's output of logs. (Gen.)

Cut a log, to. To move one end of a log forward or backward, so that the log will roll in the desired direction. (Gen.)

Cut-off. An artificial channel by which the course of a stream is straightened to facilitate log driving. (N. F.)

Deacon seat. The bench in front of the sleeping bunks in a logging camp. (N. F.)

Deadener, *n.* A heavy log or timber, with spikes set in the butt end, so fastened in a log slide that the logs passing under it come in contact with the spikes and have their speed retarded. (Gen.)

Deadhead, *n.* A sunken or partly sunken log. (Gen.)
Syn.: sinker (Gen.), bobber (N. F.).

Deadman, *n.* A fallen tree on the shore, or a timber to which the hawser of a boom is attached. (N. F., P. C. F.)

Deadwater. *See* Stillwater.

Decker, *n.* One who rolls logs upon a skidway or log deck. (Gen.)

Decking chain. *See* Loading chain.

Deck up, to. To pile logs upon a skidway. (Gen.)

Deer foot. A V-shaped iron catch on the side of a logging car, in which the binding chain is fastened. (Gen.)

Dehorn, *v.* To saw off the ends of logs bearing the owner's mark and put on a new mark. (Kentucky.)

Dingle, *n.* The roofed-over space between the kitchen and the sleeping quarters in a logging camp, commonly used as a storeroom. (N. W., L. S.)

Dinkey, *n.* A small logging locomotive. (App., S. F.)

Dog, *n.* A short, heavy piece of steel, bent and pointed at one end and with an eye or ring at the other. It is used for many purposes in logging, and is sometimes so shaped that a blow directly against the line of draft will loosen it. (Gen.)
Syn.: tail hook. (P. C. F.)

Dog boat. *See* Rigging sled.

Dogger, *n.* One who attaches the dogs or hooks to a log before it is steam skidded. (S. F., P. C. F.)

Dog hook. 1. The strong hook on the end of a dogwarp. (N. F.)
2. A hook on the end of a haul-up chain of a size to permit its being hooked into a link of the chain when the latter is looped around a log or other object. (P. C. F.)

Dogs, *n.* *See* Skidding tongs.

Dogwarp, *n.* A rope with a strong hook on the end, which is used in breaking dangerous jams on falls and rapids and in moving logs from other difficult positions. (N. F.)

Dog wedge. An iron wedge with a ring in the butt, which is driven into the end of a log and a chain hitched in the ring for skidding the log by horse power; also used in gathering up logs on a drive by running a rope through the rings and pulling a number of logs at a time through marshes or partially submerged meadows to the channel. (N. F.)

Dolly, *n.* *See* Upright roller.

Dolphin, *n.* A cluster of piles to which a boom is secured. (P. C. F.)

Donkey, *n.* A portable steam engine, equipped with drum and cable, used in steam logging. *See* Road donkey; Yarding donkey; Bull donkey; Spool donkey. (P. C. F.)

Donkey sled. The heavy sled-like frame upon which a donkey engine is fastened. (P. C. F.)

Dote, *n.* The general term used by lumbermen to denote decay or rot in timber. (Gen.)

Doty, *a.* Decayed. (Gen.)
Syn.: dozy.

Double couplers. Two coupling grabs joined by a short cable, used for fastening logs together. (P. C. F.)
Syn.: four paws.

Double header. A place from which it is possible to haul a full load of logs to the landing, and where partial loads are topped out or finished to the full hauling capacity of teams. (N. W., L. S.)

Down-hill clevis. A brake on a logging sled, consisting of a clevis encircling the runner, to the bottom of which a heavy square piece of iron is welded. (N. F.)

Dozy, *a.* *See* Doty.

Drag cart. *See* Bummer.

Drag in, to. *See* Dray in, to.

Drag road. *See* Dray road; Gutter road.

Drag sled. *See* Dray.

Draw hook. *See* Gooseneck.

Draw skid. *See* Brow skid.

Dray, *n.* A single sled used in dragging logs. One end of the log rests upon the sled. (N. F.)
Syn.: bob, crotch, drag sled, go-devil, lizard, scoot, skidding sled, sloop, travois.

Dray in, to. To drag logs from the place where they are cut directly to the skidway or landing. (N. F.)
Syn.: drag in, to.

Dray road. A narrow road, cut wide enough to allow the passage of a team and dray. (N. F.)
Syn.: drag road.

Drive, *v.* To float logs or timbers from the forest to the mill or shipping point. (Gen.)
Syn.: float.

Drive, *n.* 1. A body of logs or timbers in process of being floated from the forest to the mill or shipping point. (Gen.)
2. That part of logging which consists in floating logs or timbers. (Gen.)

Drum logs, to. To haul logs by drum and cable out of a hollow or cove. (App.)

Dry-ki, *n.* Trees killed by flooding. (N. F.)

Dry pick, to. As applied to a jam, to remove logs singly while the water is cut off. (N. F.)

Dry roll, to. In sacking the rear, to roll stranded logs into the bed of the stream from which the water has been cut off preparatory to flooding. (N. F.)

Dry rot. Decay in timber without apparent moisture. (Gen.)

Dry slide. *See* Slide.

Dry sloop, to. To sloop logs on bare ground when the slope is so steep that it would be dangerous to sloop on snow. (N. F.)

Dudler, *n.* *See* Dudley.

Dudley, *n.* An engine for hauling logs, which propels itself and drags its load by revolving a large spool around which are several turns of a cable fixed at each end of the track. (P. C. F.)

Syn.: dudler.

Duffle, *n.* The personal belongings of a woodsman or lumberjack which he takes into the woods. (Gen.)

Syn.: dunnage. (N. W.)

Dump hook. A levered chain grab hook attached to the evener to which a team is hitched in loading logs. A movement of the lever releases the hook from the logging chain without stopping the team. (N. F.)

Dump logs, to. To roll logs over a bluff, or from a logging car or sled into the water. (Gen.)

Dunnage, *n.* *See* Duffle.

Dust a dam, to. To fill up with earth or gravel the cracks or small holes between planks in the gate of a splash dam. (N. W.)

Dutchman, *n.* A short stick placed transversely between the outer logs of a load to divert the load toward the middle and so keep any logs from falling off. (N. F.)

End mark. *See* Mark.

Estimate, *v.* *See* Cruise.

Estimator, *n.* *See* Cruiser.

Face log. *See* Head log.

Faller, *n.* One who fells trees. (Gen.) *See* Head faller; Second faller.

Syn.: sawyer (Gen.), chopper (App.).

Falling ax. An ax with a long helve and a long, narrow bit, designed especially for felling trees. (Gen.)

Falling wedge. A wedge used to throw a tree in the desired direction, by driving it into the saw kerf. (Gen.)

Feeder, *n.* *See* Barn boss.

Fender boom. *See* Sheer boom.

Fender skid. A skid placed on the lower side of a skidding trail on a slope to hold the log on the trail while being skidded. (Gen.)

Syn.: breastwork log, glancer, sheer skid.

Fid hook. A slender, flat hook used to keep another hook from slipping on a chain. (N. W., L. S.)

Filer, *n.* One who files the crosscut saws in the woods. (Gen.)

Syn.: saw fitter.

Fitter, *n.* 1. One who notches the tree for felling and after it is felled marks the log lengths into which it is to be cut. (N. F.)

2. One who cuts limbs from felled trees and rings and slits the bark preparatory to peeling tanbark. (N. F.)

Float, *v*. *See* Drive.

Float road. A channel cleared in a swamp and used to float cypress logs from the woods to the boom at the river or mill. (S. F.)

Flood, *v*. *See* Splash.

Flood dam. *See* Splash dam.

Flume, *v*. To transport logs or timbers by a flume. (Gen.)

Syn.: sluice.

Flume, *n*. An inclined trough in which water runs, used in transporting logs or timbers. (Gen.)

Syn.: sluice, water slide, wet slide.

Flunkey, *n*. 1. An assistant, usually either to the engineer of a donkey engine or to the cook in a logging camp. (P. C. F.)

2. *See* Chore boy.

Flying drive. A drive the main portion of which is put through with the utmost dispatch, without stopping to pick rear. (N. F.)

Fly rollway. A skidway or landing on a steep slope, from which the logs are released at once by removing the brace which holds them. (N. F.)

Fore-and-aft road. A skid road made of logs placed parallel to its direction, making the road resemble a chute. (P. C. F.)

Syn.: stringer road.

Four paws. *See* Double couplers.

Frog, *n*. 1. The junction of two branches of a flume. (P. C. F.)

2. A timber placed at the mouth of a slide to direct the discharge of the logs. (Gen.) Syn.: throw out.

Full scale. Measurement of logs, in which no reduction is made for defects. (Gen.)

Syn.: bigness scale. (N. F.)

Gangway, *n*. The incline plane up which logs are moved from the water into a sawmill. (Gen.)

Syn.: jack ladder, log jack, log way, slip.

Gap stick. The pole placed across the entrance of a sorting jack to close it, when not in use. (Gen.)

Gee throw. A heavy, wooden lever, with a curved iron point, used to break out logging sleds. (N. F.)

Syn.: starting bar.

Gin pole. A pole secured by guy ropes, to the top of which tackle for loading logs is fastened. (Gen.)

Glancer, *n*. *See* Fender skid.

Glancing boom. *See* Sheer boom.

Glisse skids. Freshly peeled skids up which logs are slid instead of rolled when being loaded. (N. F.)

Syn.: slip skids.

Go-back road. A road upon which unloaded logging sleds can return to the skidways for reloading, without meeting the loaded sleds en route to the landing. (N. F.)

Syn.: short road.

Go-devil. *See* Dray.

Gooseneck, *n.* 1. A wooden bar used to couple two logging trucks. (Gen.)

Syn.: rooster. (P. C. F.)

2. The point of draft on a logging sled; it consists of a curved iron hook bolted to the roll. (N. F.)

Syn.: draw hook.

3. A curved iron driven into the bottom of a slide to check the speed of descending logs. (App.)

Goosepen. A large hole burned in a standing tree. (P. C. F.)

Grab hook. A hook having a narrow throat, adapted to grasp any link of a chain. (Gen.)

Grab link. *See* Slip grab.

Grabs, *n.* *See* Skidding tongs.

Grab skipper. A short iron pry or hammer, used to remove the skidding tongs from a log. (App., S. F.)

Grapples, *n.* 1. Two small iron dogs joined by a short chain, and used to couple logs end to end when skidding on mountains, so that several logs may be skidded by one horse at the same time. (N. F.)

Syn.: chain grapples, coupling grab. (P. C. F.)

2. *See* Skidding tongs.

Gravel a dam, to. To cover with gravel or earth the upstream side of the timber work of a dam, to make it water tight. (N. F.)

Greaser, *n.* *See* Road monkey.

Grips, *n.* *See* Skidding tongs.

Ground loader. *See* Send-up man.

Grouser, *n.* A large and long stick of squared timber sharpened at the lower end and placed in the bow of a steam logging boat; it takes the place of an anchor in shallow water, and can be raised or lowered by steam power. (N. W., L. S.)

Guard a hill, to. To keep a logging road on a steep decline in condition for use. (N. F.)

Gun, *v.* To aim a tree in felling it. In the case of very large, brittle trees, such as redwood, a sighting device (gunning stick) is used. (P. C. F.)

Syn.: point, swing. (Gen.)

Gunning stick. *See* Gun.

Gutterman. *See* Swamper.

Gutter road. The path followed in skidding logs. (Gen.)

Syn.: drag road, runway, skidding trail, snaking trail.

Handbarrow. Two strong, light poles held in position by rungs, upon which bark or wood is carried by two men. (N. W., L. S.)
Syn.: ranking bar.

Hand pike. A piked lever, usually from 6 to 8 feet long, for handling floating logs. (Gen.)

Hand skidder. One who accompanies a log as it is being dragged and places short skids beneath it. (P. C. F.)

Hang the boom, to. To put the boom in place. (Gen.)

Hang up, to. 1. To fell a tree so that it catches against another instead of falling to the ground. (Gen.)
Syn.: lodge (Gen.), buckwheat (App.)
2. As applied to river driving, to discontinue; thus a drive may be "hung up" for lack of water or for some other reason.

Hardwood, *a.* As applied to trees and logs, broadleafed, belonging to the dicotyledons. (Gen.)
Syn.: broadleaf.

Hardwood, *n.* A broadleafed, or dicotyledonous, tree. (Gen.)

Haul, *n.* In logging, the distance and route over which teams must go between two given points, as between the yard or skidway and the landing. (Gen.)

Haul back. A small wire rope, traveling between the donkey engine and a pulley set near the logs to be dragged, used to return the cable. (P. C. F.)
Syn.: back line, pull back, trip line.

Haul up. A light chain and hook by which a horse may be hitched to a cable in order to move it where desired. (P. C. F.)

Hay road. *See* Tote road.

Hay wire outfit. A contemptuous term for loggers with poor logging equipment. (N. F.)

Head block. The log placed under the front end of the skids in a skidway to raise them to the desired height. (N. F.)

Head driver. An expert river driver who, during the drive, is stationed at a point where a jam is feared. Head drivers usually work in pairs. (N. F.)
Syn.: log watch (N. F.), jam cracker (P. C. F.)

Head faller. The chief of a crew of fallers. (P. C. F.)

Head log. 1. The front bottom log on a skidway. (N. F.)
Syn.: face log.
2. The front log in a turn. (P. C. F.)
Syn.: lead log.

Head push. *See* Straw boss.

Headquarters, *n.* In logging, the distributing point for supplies, equipment and mail; not usually the executive or administrative center. (Gen.)

Head tree. In steam skidding, the tree to which the cable upon which the traveler runs is attached. (S. F.)

Headworks, *n.* A platform or raft, with windlass or capstan, which is attached to the front of a log raft or boom of logs, for warping, kedging or winding it through lakes and still water, by hand or horse power. (N. W., L. S.)

Helper, *n.* *See* Second faller.

Hoist, *n.* *See* Loading tripod.

Holding boom. *See* Storage boom.

Hook tender. The foreman of a yarding crew; specifically, one who directs the attaching of the cable to a turn of logs. (P. C. F.)

Horse dam. A temporary dam made by placing large logs across a stream, in order to raise the water behind it, so as to float the rear. (N. F.)

Horse logs, to. In river driving, to drag stranded logs back to the stream by the use of peaveys. (N. F.)

Hovel, *n.* A stable for logging teams. (N. W., L. S.)

Ice a road, to. To sprinkle water on a logging road so that a coating of ice may form, thus facilitating the hauling of logs. (N. F.)

Ice guards. Heavy timbers fastened fan shaped about a cluster of boom piles at an angle of approximately 30 degrees to the surface of the water. They prevent the destruction of the boom by ice, through forcing it to mount the guards and be broken up. (N. F.)

Jack chain. An endless spiked chain, which moves logs from one point to another, usually from the mill pond into the sawmill. (Gen.)

Syn.: bull chain. (P. C. F.)

Jack ladder. *See* Gangway.

Jackpot, *n.* 1. A contemptuous expression applied to an unskilful piece of work in logging. (N. F.)

2. An irregular pile of logs. (App.)

Jam, *n.* A stoppage or congestion of logs in a stream, due to an obstruction or to low water. (Gen.)

Jam cracker. *See* Head driver.

Jammer, *n.* An improved form of gin, mounted on a movable framework, and used to load logs on sleds and cars by horse power. (N. F.)

Jam, to break a. To start in motion logs which have jammed. (Gen.)

Jay hawk, to. To strip one 4-foot length of bark from a tanbark oak, leaving the tree standing. (P. C. F.)

Jiboo, *v.* To remove a dog from a log. (N. W., L. S.)

Jigger, *v.* To pull a log by horse power over a level place in a slide. (Gen.)

Syn.: lazy haul, to.

Jim binder. *See* Binder.

Jobber, *n.* A logging contractor or subcontractor. (Gen.)

Jobber's sun. A term applied to the moon in a jobber's or contractor's logging camp, on account of the early and late hours of commencing and ending work. (N. W., L. S.)

Jumper, *n.* A sled shod with wood, used for hauling supplies over bare ground into a logging camp. (N. F.)
Syn.: tote sled.

Katydid, *n.* *See* Logging wheels.

Key log. In river driving, a log which is so caught or wedged that a jam is formed and held. (Gen.)

Kilhig, *n.* A short, stout pole used as a lever or brace to direct the fall of a tree. (N. W.)

Knot, *v.* *See* Limb.

Knot bumper. *See* Limber.

Knotter, *n.* *See* Limber.

Laker, *n.* A log driver expert at handling logs on lakes. (N. F.)

Landing, *n.* 1. A place to which logs are hauled or skidded preparatory to transportation by water or rail. A *rough and tumble landing* is one in which no attempt is made to pile the logs regularly. (Gen.)
Syn.: bank, banking ground, log dump, rollway, yard.
2. A platform, usually at the foot of a skid road, where logs are collected and loaded on cars. A *lightning landing* is one having such an incline that the logs may roll upon the cars without assistance. (Gen.)

Landing man. One who unloads logging sleds at the landing. (N. F.)

Landing, to break a. To roll a pile of logs from a landing or bank into the water. (Gen.)

Land looker. *See* Cruiser.

Lap, *n.*, or **Lapwood,** *n.* Tops left in the woods in logging. (Gen.)

Lash pole. A cross pole which holds logs together in a raft. (Gen.)

Lazy haul, to. *See* Jigger.

Lead, *n.* A snatch block with a hook or loop for fastening it to convenient stationary objects, used for guiding the cable by which logs are dragged. (P. C. F.)

Lead line. A wire rope, with an eye at each end, used to anchor the snatch block in setting a lead. (P. C. F.)

Lead log. *See* Brow skid; Head log.

Lightning landing. *See* Landing.

Limb, *v.* To remove the limbs from a felled tree.
Syn.: knot. (P. C. F.)

Limber, *n.* One who cuts the limbs from felled trees. (Gen.)
Syn.: knotter (P. C. F.), knot bumper (App.).

Line horse. The horse which drags the cable from the yarding engine to the log to which the cable is to be attached. (P. C. F.)

Lizard, *n.* *See* Dray.

Loader, *n.* 1. One who loads logs on sleds or cars. (Gen.)
2. *See* Steam loader.

Loading chain. A long chain used in loading or piling logs with horses. (N. F.)
Syn.: decking chain.

Loading jack. A platformed framework upon which logs are hoisted from the water for loading upon cars. (N. F.)

Loading tripod. Three long timbers joined at their tops in the shape of a tripod, for holding a pulley block in proper position to load logs on cars from a lake or stream. (L. S.)
Syn.: hoist.

Lock down. A strip of tough wood, with holes in the ends, which is laid across a raft of logs. Rafting pins are driven through the holes into the logs, thus holding the raft together. (N. F.)

Lodge, to. *See* Hang up, to.

Logan, *n.* *See* Pokelogan.

Log deck. The platform upon a loading jack. (Gen.)

Log dump. *See* Landing.

Log fixer. *See* Rosser.

Logger, *n.* One engaged in logging.

Logging sled. The heavy double sled used to haul logs from the skidway or yard to the landing. (N. F.)
Syn.: twin sleds, two sleds, wagon sled.

Logging-sled road. A road, leading from the skidway to the landing. (N. F.)

Logging wheels. A pair of wheels, usually about 10 feet in diameter, for transporting logs. (Gen.)
Syn.: big wheels, katydid, timber wheels.

Log jack. *See* Gangway.

Log scale. The contents of a log, or of a number of logs considered collectively. (Gen.)

Log, to. To cut logs and deliver them at a place from which they can be transported by water or rail, or, less frequently, at the mill. (Gen.)

Log watch. *See* Head driver.

Logway, *n.* *See* Gangway.

Long butt, to. *See* Butt off, to.

Loose-tongued sloop. *See* Swing dingle.

Lubber lift, to. To raise the end of a log by means of a pry, and through the use of weight instead of strength. (N. F.)

Lug hooks. A pair of tongs attached to the middle of a short bar, and used by two men to carry small logs. (Gen.)

Lumber, *v.* To log, or to manufacture logs into lumber, or both. (Gen.)

Lumberjack, *n.* One who works in a logging camp. (Gen.)

Lumberman, *n.* One engaged in lumbering. (Gen.)

Mark, *n.* A letter or sign indicating ownership, which is stamped on the ends of logs. (Gen.) *See* Bark mark.
Syn.: brand, end mark.

Mark caller. In sorting logs, one who stands at the lower end of the sorting jack and calls the different marks, so that the logs may be guided into the proper channels or pockets. (Gen.)

Marker, *n.* One who puts the mark on the ends of logs. (Gen.)

Market, *n.* A log 19 inches in diameter at the small end and 13 feet long. (New York.)

Syn.: standard.

Marking hammer. A hammer bearing a raised device, which is stamped on logs, to indicate ownership. (Gen.)

Syn.: marking iron.

Marking iron. *See* Marking hammer.

Match, *v.* *See* Mate.

Mate, *v.* To place together in a raft logs of similar size. (Gen.)

Syn.: match.

Mill pond. The pond near a sawmill in which logs to be sawn are held. (Gen.)

Monitor. *See* Catamaran.

Moss, *v.* To fill with moss the crevices between the logs in a logging camp. (N. F.)

Mud, *v.* To fill with soft clay the crevices between the logs in a logging camp. (N. F.)

Mudboat, *n.* A low sled with wide runners, used for hauling logs in swamps. (S. F., N. F.)

Mudsill, *n.* The bed piece or bottom timber of a dam which is placed across the stream, usually resting on rocks or in mud. (Gen.)

Syn.: bottom sill.

Nick, *n.* *See* Undercut.

Nose, *v.* To round off the end of a log in order to make it drag or slip more easily. (Gen.)

Syn.: snipe.

Notch, *v.* To make an undercut in a tree preparatory to felling it. (Gen.)

Syn.: undercut.

Notch, *n.* *See* Undercut.

Peaker, *n.* 1. A load of logs narrowing sharply toward the top, and thus shaped like an inverted V. (Gen.)

2. The top log of a load. (Gen.)

Peavey, *n.* A stout lever, from 5 to 7 feet long, fitted at the larger end with a metal socket and pike and a curved steel hook which works on a bolt; used in handling logs, especially in driving. A peavey differs from a cant hook in having a pike instead of a toe ring and lip at the end. (Gen.)

Pecky, *a.* A term applied to an unsoundness most common in bald cypress. (S. F.)

Syn.: peggy.

Peeler, *n.* *See* Barker.

Peggy, *a.* *See* Pecky.

Pickaroon, *n.* A piked pole fitted with a curved hook, used in holding boats to jams in driving, and for pulling logs from brush and eddies out into the current. (Gen.)

Pick the rear, to. *See* Sack the rear, to.

Pier dam. A pier built from the shore, usually slanting downstream, to narrow and deepen the channel, to guide logs past an obstruction, or to throw all the water on one side of an island. (N. F.)

Syn.: wing dam.

Pig, *n.* *See* Rigging sled.

Pig tail. An iron device driven into trees or stumps to support a wire or small rope. (P. C. F.)

Pike pole. A piked pole, from 12 to 20 feet long, used in river driving. (Gen.)

Pitch pocket. A cavity in wood filled with resin. (P. C. F., R. M. F., S. F.)

Pitch streak. A seam or shake filled with resin. (Gen.)

Plug and knock down. A device for fastening boom sticks together, in the absence of chains. It consists of a withe secured by wooden plugs in holes bored in the booms. (N. F.)

Pocket boom. A boom in which logs are held after they are sorted. (Gen.)

Point, *v.* *See* Gun.

Pokelogan, *n.* A bay or pocket into which logs may float off during a drive. (N. W., L. S.)

Syn.: logan.

Pond man. One who collects logs in the mill pond and floats them to the gangway. (Gen.)

Pontoon. *See* Catamaran.

Prize logs. Logs which come to the sorting jack without marks denoting ownership. (N. F.)

Pull back. *See* Haul back.

Pullboat. A flatboat, carrying a steam skidder or a donkey, used in logging cypress. (S. F.)

Pull the briar, to. To use a crosscut saw. (N. F.)

Put in, to. In logging, to deliver logs at the landing. (Gen.)

Quickwater, *n.* That part of a stream which has fall enough to create a decided current. (Gen.)

Ant.: stillwater.

Rafter dam. A dam in which long timbers are set on the upstream side at an angle of from 20 to 40 degrees to the water surface. The pressure of the water against the timbers holds the dam solidly against the stream bed. (N. F.)

Syn.: self-loading dam, slant dam.

Ram pike. A tree broken off by wind and with a splintered end on the portion left standing. (N. F.)

Rank, *v.* To haul and pile regularly, as, to *rank* bark or cord wood. (Gen.)

Ranking bar. *See* Handbarrow.

Ranking jumper. A wood-shod sled upon which tanbark is hauled. (N. F.)

Rave, *n.* A piece of iron or wood which secures the beam to the runners of a logging sled. (N. W., L. S.)

Rear, *n.* The upstream end of a drive; the logs may be either stranded or floating. "Floating rear" comprises those logs which may be floated back into the current; "dry rear," those which must be dragged or rolled back. (Gen.)

Receiving boom. *See* Storage boom.

Ride, *n.* The side of a log upon which it rests when being dragged. (Gen.)

Ride a log, to. To stand on a floating log. (Gen.)

Rigging, *n.* The cables, blocks and hooks used in skidding logs by steam power. (Gen.)

Rigging sled. A sled used to haul hooks and blocks on a skid road. (P. C. F.)

Syn.: dog boat, pig.

Rigging slinger. 1. A member of a yarding crew, whose chief duty is to place chokers or grabs on logs. (P. C. F.)

2. One who attaches the rigging to trees, in steam skidding. (S. F.)

Ring, *n.* A section of tanbark, usually 4 feet long. (N. F.)

Ring rot. Decay in a log, which follows the annual rings more or less closely. (Gen.)

Rise, *n.* The difference in diameter, or taper, between two points in a log. (Gen.)

River boss. The foreman in charge of a log drive. (N. F.)

River driver. One who works on a log drive. (Gen.)

River rat. A log driver whose work is chiefly on the river; contrasted with Laker. (N. F.)

Road donkey. A donkey engine mounted on a heavy sled, which drags logs along a skid road by winding a cable on a drum. It has a second drum for the haul back. (P. C. F.)

Road gang. That portion of the crew of a logging camp who cut out logging roads and keep them in repair. (N. F.)

Road monkey. One whose duty is to keep a logging road in proper condition. (N. W., L. S.)

Syn.: blue jay, greaser. (P. C. F.)

Roll, *n.* The crossbar of a logging sled into which the tongue is set. (N. W., L. S.)

Syn.: roller.

Roller, *n.* *See* Roll; Upright roller.

Rolling dam. A dam for raising the water in a shallow stream. It has no sluiceways, but a smooth top of timber over which, under a sufficient head of water, logs may slide or roll. (Gen.)

Roll the boom, to. To roll a boom of logs along the shore of a lake against which it is held by wind, by the use of a cable operated by a steamboat or kedge. The cable is attached to the outer side of the boom, hauled up, then attached again, thus propelling the boom by revolving it against the shore when it would be impossible to tow it. (N. W., L. S.)

Rollway, *n.* *See* Landing.

Rooster, *n.* *See* Gooseneck.

Rosser, *n.* One who barks and smooths the ride of a log in order that it may slide more easily. (N. F.)

Syn.: log fixer (P. C. F.), slipper, scalper (App.).

Rough and tumble landing. *See* Landing.

Round timber. Pine trees which have not been turpentined. (S. F.)

Round turn. A space at the head of a logging-sled road, in which the sled may be turned round without unhitching the team. (N. F.)

Runner chain. A chain bound loosely around the forward end of the runners of a logging sled as a brake. (N. W., L. S.)

Runner dog. A curved iron attached to a runner of the hind sled of a logging sled, which holds the loaded sled on steep hills by being forced into the bed of the road by any backward movement. (N. F.)

Runway. *See* Gutter road.

Rutter, *n.* A form of plow for cutting ruts in a logging road for the runners of the sleds to run in. (N. W., L. S.)

Sack the rear, to. To follow a drive and roll in logs which have lodged or grounded. (Gen.)

Syn.: pick the rear, to.

Sack the slide, to. To return to a slide logs which have jumped out. (Gen.)

Saddle, *n.* The depression cut in a transverse skid in a skid road to guide the logs which pass over it. (P. C. F.)

Saddlebag, *v.* As applied to a boom, to catch on an obstruction and double around it. (Gen.)

Sampson, *n.* An appliance for loosening or starting logs by horse power. It usually consists of a strong, heavy timber and a chain terminating in a heavy swamp hook. The timber is placed upright beside the piece to be moved, the chain fastened around it, and the hook inserted low down on the opposite side. Leverage is then applied by a team hitched to the upper end of the upright timber. (N. F.)

Sampson a tree, to. To direct the fall of a tree by means of a lever and pole. (N. F.)

Sap stain. Discoloration of the sapwood. (Gen.)

Saw fitter. *See* Filer.

Sawyer, *n.* *See* Faller.

Scale book. A book especially designed for recording the contents of scaled logs. (Gen.)

Scaler, *n.* One who determines the volume of logs. (Gen.)

Scalper, *n.* *See* Rosser.

Scoot, *n.* *See* Dray.

Season check. *See* Check.

Second faller. The subordinate in a crew of fallers. (P. C. F.)
Syn.: helper. (N. F.)

Self-loading dam. *See* Rafter dam.

Send-up man. That member of a loading crew who guides the logs up the skids. (Gen.)
Syn.: ground loader. (N. F.)

Send up, to. In loading, to raise logs up skids with cant hooks, or by steam or horse power. (Gen.)

Setting, *n.* The temporary station of a portable sawmill, a yarding engine, or other machine used in logging. (Gen.)

Shake, *n.* A crack in timber, due to frost or wind. (Gen.)
Syn.: windshake.

Shanty boat. *See* Wanigan.

Shanty boss. *See* Chore boy.

Sheer boom. A boom so secured that it guides floating logs in the desired direction. (N. F.)
Syn.: fender boom, glancing boom.

Sheer skid. *See* Fender skid.

Shoot a jam, to. To loosen a log jam with dynamite. (Gen.)

Shore hold. The attachment of the hawser of a raft of logs to an object on the shore. (N. W., L. S.)

Short road. *See* Go-back road.

Shot holes. Holes made in wood by boring insects. (App.)

Side jam. A jam which has formed on one side of a stream, usually where the logs are forced to the shore at a bend by the current, or where the water is shallow or there are partially submerged rocks. (N. F.)

Side mark. *See* Bark mark.

Side winder. A tree knocked down unexpectedly by the falling of another. (Gen.)

Signal man. One who transmits orders from the foreman of a yarding crew to the engineer of the yarding donkey. (P. C. F.)

Single out, to. To float logs, usually cypress, one at a time, from the woods to the float road. (S. F.)

Sinker, *n.* *See* Deadhead.

Sinker boat. *See* Catamaran.

Skid, *v.* 1. To draw logs from the stump to the skidway, landing or mill. (Gen.)
Syn.: snake, twitch.

2. As applied to a road, to reinforce by placing logs or poles across it. (Gen.)

Skid, *n.* A log or pole, commonly used in pairs, upon which logs are handled or piled (Gen.); or the log or pole laid transversely in a skid road (P. C. F.).

Skidder, *n.* 1. One who skids logs. (Gen.)

2. A steam engine, usually operating from a railroad track, which skids logs by means of a cable. (Gen.)

Syn.: steam skidder.

3. The foreman of a crew which constructs skid roads. (P. C. F.)

4. *See* Bummer.

Skidding chain. A heavy chain used in skidding logs. (Gen.)

Skidding hooks. *See* Skidding tongs.

Skidding sled. *See* Dray.

Skidding tongs. A pair of hooks attached by links to a ring and used for skidding logs. (Gen.)

Syn.: grips, grapples, grabs, skidding hooks.

Skidding trail. *See* Gutter road.

Skid grease. A heavy oil applied to skids to lessen the friction of logs dragged over them. (P. C. F.)

Skid road. 1. A road or trail leading from the stump to the skidway or landing. (Gen.)

Syn.: travois road. (N. F.)

2. A road over which logs are dragged, having heavy transverse skids partially sunk in the ground, usually at intervals of about 5 feet. (P. C. F.)

Skid up, to. 1. To level or reinforce a logging road by the use of skids. (Gen.)

2. To collect logs and pile them on a skidway. (Gen.)

Skidway, *n.* Two skids laid parallel at right angles to a road, usually raised above the ground at the end nearest the road. Logs are usually piled upon a skidway as they are brought from the stump for loading upon sleds, wagons or cars. (Gen.)

Skidway, to break a. To roll piled logs off a skidway. (Gen.)

Sky hooker. *See* Top loader.

Slack water. In river driving, the temporary slackening of the current caused by the formation of a jam. (Gen.)

Slant dam. *See* Rafter dam.

Slash, *n.* 1. The débris left after logging, wind or fire. (Gen.)

Syn.: slashing.

2. Forest land which has been logged off and upon which the limbs and tops remain, or which is deep in débris as the result of fire or wind. (Gen.)

Slashing, *n.* *See* Slash.

Sled tender. 1. One who assists in loading and unloading logs or skidding with dray. (N. F.)

Syn.: chain tender.

2. A member of the hauling crew who accompanies the turn of logs to the landing, unhooks the grabs, and sees that they are returned to the yarding engine. (P. C. F.)

Slide, *n.* A trough built of logs or timber, used to transport logs down a slope. (Gen.)

Syn.: chute, dry slide, slip.

Slide tender. One who keeps a slide in repair. (Gen.)

Slip, *n.* 1. *See* Slide.

2. *See* Gangway.

Slip grab. A pear-shaped link attached by a swivel to a skidding evener or whiffletree, through which the skidding chain is passed. The chain runs freely when the slip grab is held sideways, but catches when the grab is straight. (N. F.)

Syn.: grab link.

Slipper, *n.* *See* Rosser.

Slip skids. *See* Glisse skids.

Sloop, *n.* *See* Dray.

Sloop logs, to. To haul logs down steep slopes on a dray or sloop equipped with a tongue. (N. F.)

Slough pig. Usually a second-rate river driver who is assigned to picking logs out of sloughs in advance of the rear. (N. F.)

Sluice, *v.* 1. *See* Flume.

2. To float logs through the sluiceway of a splash dam. (N. F.)

3. *See* Splash.

Sluice, *n.* *See* Flume.

Sluice gate. The gate closing a sluiceway in a splash dam. (Gen.)

Sluiceway, *n.* The opening in a splash dam through which logs pass. (Gen.)

Snake, *v.* *See* Skid.

Snaking trail. *See* Gutter road.

Snatch team. *See* Tow team.

Snib, *v.* In river driving, to be carried away purposely, but ostensibly by accident, on the first portion of a jam that moves; to ride away from work under guise of being accidently carried off. (N. W., L. S.)

Snipe, *v.* *See* Nose.

Sniper, *n.* One who noses logs before they are skidded. (Gen.)

Snow a road, to. To cover bare spots in a logging road with snow to facilitate the passage of sleds. (N. F.)

Snow slide. A temporary slide on a steep slope, made by dragging a large log through deep snow which is soft or thawing; when frozen solidly, it may be used to slide logs to a point where they can be reached by sleds. (N. W.)

Snub, *v.* To check, usually by means of a snub line, the speed of logging sleds or logs on steep slopes, or of a log raft. (Gen.)

Softwood, *a.* As applied to trees and logs, needle-leafed, coniferous. (Gen.)

Softwood, *n.* A needle-leafed, or coniferous, tree. (Gen.)

Solid jam. 1. In river driving, a jam formed solidly and extending from bank to bank of a stream. (N. F.)

2. A drive is said to be " in a solid jam " when the stream is full of logs from the point to which the rear is cleared to the mill, sorting jack or storage boom. (N. F.)

Sorting boom. A strong boom used to guide logs into the sorting jack, to both sides of which it is usually attached. (Gen.)

Sorting gap. *See* Sorting jack.

Sorting jack. A raft, secured in a stream, through an opening in which logs pass to be sorted by their marks and diverted into pocket booms or the downstream channel. (Gen.)

Syn.: sorting gap.

Spanish windlass. A device for moving heavy objects in logging. It consists of a rope or chain, within a turn of which a lever is inserted and power gained by twisting. (N. F.)

Syn.: twister.

Spiked skid. A skid in which spikes are inserted in order to keep logs from sliding back when being loaded or piled. (Gen.)

Splash, *v.* To drive logs by releasing a head of water confined by a splash dam. (Gen.)

Syn.: flood, sluice.

Splash boards. Boards placed temporarily on top of a rolling dam to heighten the dam, and thus to increase the head of water available for river driving. (N. F.)

Splash dam. A dam built to store a head of water for driving logs. (Gen.)

Syn.: flood dam. (Gen.)

Split roof. A roof of a logging camp or barn made by laying strips split from straight-grained timber. The strips run from the ridge pole to the eaves, and break the joints with other strips, as in a shingle roof. (N. F.)

Spool donkey. A donkey engine for winding cable, equipped with a spool or capstan, instead of a drum. (P. C. F.)

Spool tender. One who guides the cable on a spool donkey. (P. C. F.)

Spot, *v.* *See* Blaze.

Spring board. A short board, shod at one end with an iron calk, which is inserted in a notch cut in a tree, on which the faller stands while felling the tree. (P. C. F., S. F.)

Spring pole. 1. A springy pole attached to the tongue of a logging sled and passing over the roll and under the beam, for holding the weight of the tongue off the horses' necks. (N. F.)

2. A device for steadying a crosscut saw, so that one man can use it instead of two. (P. C. F.)

Sprinkler, *n.* A large wooden tank from which water is sprinkled over logging roads during freezing weather in order to ice the surface. (N. W., L. S.)

Syn.: tank.

Sprinkler sleds. The sleds upon which the sprinkler is mounted. They consist of two sleds whose runners turn up at each end, fastened together by cross chains, and each having a pole, in order that the sprinkler may be hauled in either direction without turning around. (N. F.)

Spud, *n.* A tool for removing bark. (Gen.)

Syn.: barking iron.

Spudder, *n.* *See* Barker.

Stag, *v.* To cut off trousers at the knee, or boots at the ankle. (N. F., P. C. F.)

Standard, *n.* *See* Market.

Starting bar. *See* Gee throw.

Stay boom. A boom fastened to a main boom and attached upstream to the shore to give added strength to the main boom. (Gen.)

Steam hauler. A geared locomotive used to haul loaded logging sleds over an ice road. It is equipped with a spiked metal belt which runs over sprocket wheels replacing the driving wheels, and is guided by a sled, turned by a steering wheel, upon which the front end rests. (N. F.)

Steam jammer. *See* Steam loader.

Steam loader. A machine operated by steam and used for loading logs upon cars. (Gen.)

Syn.: loader, steam jammer.

Steam skidder. *See* Skidder.

Stem winder. *See* Corkscrew.

Stillwater. That part of a stream having such slight fall that no current is apparent. Ant.: quickwater. (Gen.)

Syn.: deadwater.

Stock logs, to. To deliver logs from stump to mill or railroad. (S. F.)

Storage boom. A strong boom used to hold logs in storage at a sawmill. (Gen.)

Syn.: holding boom, receiving boom.

Straw boss, *n.* A subforeman in a logging camp. (N. W., L. S.)

Syn.: head push.

Stream jam. *See* Center jam.

Stringer road. *See* Fore-and-aft road.

Stumpage, *n.* The value of timber as it stands uncut in the woods; or, in a general sense, the standing timber itself. (Gen.)

Swamp, *v.* To clear the ground of underbrush, fallen trees and other obstructions preparatory to constructing a logging road or opening out a gutter road. (Gen.)

Swamper, *n.* One who swamps. (Gen.)
Syn.: beaver, gutterman. (N. F.)

Swamp hook. A large, single hook on the end of a chain, used in handling logs, most commonly in skidding. (Gen.)

Sway bar. 1. A strong bar or pole, two of which couple and hold in position the front and rear sleds of a logging sled. (N. F.)
2. The bar used to couple two logging cars. (Gen.)

Swell butted. As applied to a tree, greatly enlarged at the base. (Gen.)
Syn.: bottle butted, churn butted.

Swing, *v.* *See* Gun.

Swing dingle. A single sled with wood-shod runners and a tongue with lateral play, used in hauling logs down steep slopes on bare ground. (N. F.)
Syn.: loose-tongued sloop.

Swing team. In a logging team of six, the pair between the leaders and the butt team. (P. C. F.)

Tail chain. A heavy chain bound around the trailing end of logs, as a brake, in slooping on steep slopes. (N. W.)

Taildown, to. To roll logs on a skidway to a point on the skids where they can be quickly reached by the loading crew. (N. F.)

Tail hold. 1. A means of obtaining increased power in moving a log by tackle. The cable is passed through a block attached to the log and the end fastened to a stationary object, so that hauling on the other end gives twice the power which would be attained by direct attachment of the cable to the log. (P. C. F.)
2. The attachment of the rear end of a donkey sled, usually to a tree or stump. (P. C. F.)

Tail hook. *See* Dog.

Tally board. A thin, smooth board used by a scaler to record the number or volume of logs. (Gen.)

Tally man. One who records or tallies the measurements of logs as they are called by the scaler. (N. F.)

Tank, *n.* *See* Sprinkler.

Tank conductor. One who has charge of the crew which operates a sprinkler or tank, and who regulates the flow of water, in icing logging roads. (N. F.)

Tank heater. A sheet-iron cylinder extending through a tank or sprinkler, in which a fire is kept to prevent the water in the tank from freezing while icing logging roads in extremely cold weather. (N. F.)

Tanking. The act of hauling water in a tank, to ice a logging road. (N. F.)

Tee, *n.* A strip of iron about 6 inches long with a hole in the center, to which a short chain is attached; it is passed through a hole in a gate plank, turned crosswise, and so used to hold the plank when tripped in a splash dam. (N. W.)

Throw, *v.* *See* Wedge a tree, to.

Throw line. *See* Trip line.

Throw out. *See* Frog.

Tide, *n.* A freshet. In the Appalachian region logs are rolled into a stream and a " tide " awaited to carry them to the boom. (App.)

Timber wheels. *See* Logging wheels.

Toe ring. The heavy ring or ferrule on the end of a cant hook. It has a lip on the lower edge to prevent slipping when a log is grasped. (Gen.)

Toggle chain. A short chain with a ring at one end and a toggle hook and ring at the other, fastened to the sway bar or bunk of a logging sled, and used to regulate the length of a binding chain. (N. F.)

Syn.: bunk chain.

Toggle hook. A grab hook with a long shank, used on a toggle chain. (N. F.)

Tonging, *v.* Handling logs with skidding tongs. (N. F.)

Top chains. Chains used to secure the upper tiers of a load of logs after the capacity of the regular binding chains has been filled. (Gen.)

Top load. A load of logs piled more than one tier high, as distinguished from a bunk load. (Gen.)

Top loader. That member of a loading crew who stands on the top of a load and places logs as they are sent up. (Gen.)

Syn.: sky hooker. (N. F.)

Tote, *v.* To haul supplies to a logging camp. (N. F.)

Tote road. A road used for hauling supplies to a logging camp. (N. F.)

Syn.: hay road.

Tote sled. *See* Jumper.

Tow team. An extra team stationed at an incline in a logging road to assist the regular teams in ascending with loaded sleds. (N. F.)

Syn.: snatch team.

Trailers, *n.* Several logging sleds hitched behind one another and pulled by from 4 to 8 horses driven by one man, thus saving teamster's wages. (N. F.)

Tram, *n.* *See* Tramway.

Tramway, *n.* A light or temporary railroad for the transportation of logs, often with wooden rails and operated by horse power. (Gen.)

Syn.: tram.

Travois, *n.* *See* Dray.

Travois road. *See* Skid road.

Trip, *v.* *See* Wedge a tree, to.

Trip, *n.* *See* Turn.

Trip a dam, to. To remove the plank which closes a splash dam. (N. F.)

Trip line. **1.** A light rope attached to a dog hook, used to free the latter when employed in breaking a jam, a skidway or a load. (N. F.)

Syn.: throw line.

2. *See* Haul back.

Tripsill, *n.* A timber placed across the bottom of the sluiceway in a splash dam, against which rest the planks by which the dam is closed. (Gen.)

Trough roof. A roof on a logging camp or barn, made of small logs split lengthwise, hollowed into troughs and laid from ridge pole to eaves. The joints of the lower tier are covered by inverted troughs. (N. F.)

Turkey, *n.* A bag containing a lumberjack's outfit. To "histe the turkey" is to take one's personal belongings and leave camp. (N. W., L. S.)

Turn, *n.* 1. A single trip and return made by one team in hauling logs; *e.g.*, a four-turn road is a road the length of which will permit of only four round trips per day. (N. F.)

Syn.: trip. (Gen.)

2. Two or more logs coupled together end to end for hauling. (P.C.F.)

Turnout, *n.* A short side road from a logging-sled road, to allow loaded sleds to pass. (N. W., L. S.)

Twin sleds. *See* Logging sled.

Twister, *n.* *See* Spanish windlass.

Twitch, *v.* *See* Skid.

Two sleds. *See* Logging sled.

Undercut, *v.* *See* Notch.

Undercut, *n.* The notch cut in a tree to determine the direction in which the tree is to fall, and to prevent splitting. (Gen.)

Syn.: notch (Gen.), nick (S. F.).

Undercutter, *n.* A skilled woodsman who chops the undercut in trees so that they shall fall in the proper direction. (Gen.)

Union drive. A drive of logs belonging to several owners, who share the expense pro rata. (N. F.)

Upright roller. A flanged roller placed upright at a bend in a skid road to direct the cable. (P. C. F.)

Syn.: roller, dolly.

Value, *v.* *See* Cruise.

Valuer, *n.* *See* Cruiser.

Van, *n.* The small store in a logging camp in which clothing, tobacco and medicine are kept to supply the crew. (N. W., L. S.) *See* Commissary.

Wagon sled. *See* Logging sled.

Wanigan, *n.* A houseboat used as sleeping quarters or as kitchen and dining room by river drivers. (N. W., L. S.)

Syn.: ark (N. F.), shanty boat (S. F.).

Water ladder. Pole guides up and down which a barrel slides in filling a sprinkler by horse power. (N. W., L. S.)

Water slide. *See* Flume.

Wedge a tree, to. To topple over with wedges a tree that is being felled. (Gen.)

Syn.: throw, trip.

Wet slide. *See* Flume.

Whiffletree neckyoke. A heavy logging neckyoke, to the ends of which short whiffletrees are attached by rings. From the ends of the whiffletrees wide straps run to the breeching, thus giving the team added power in holding back loads on steep slopes. (N. F.)

White water man. A log driver who is expert in breaking jams on rapids or falls. (N. F.)

Widow maker. A broken limb hanging loose in the top of a tree, which in its fall may injure a man below (N. F.), or a breaking cable (P. C. F.)

Wigwam, to make a. In felling trees, to lodge several in such a way that they support each other. (N. F.)

Windfall, *n.* An area upon which the trees have been thrown by wind; also, a single tree thrown by wind. (Gen.)

Syn.: blow down, wind slash. (N. F.)

Windshake, *n.* *See* Shake.

Wind slash. *See* Windfall.

Wing dam. *See* Pier dam.

Wing jam. A jam which is formed against an obstacle in the stream and slants upstream until the upper end rests solidly against one shore, with an open channel for the passage of logs on the opposite side. (N. F.)

Woodpecker, *n.* A poor chopper. (Gen.)

Wrapper chain. *See* Binding chain.

Yard, *n.* *See* Landing.

Yarding donkey. A donkey engine mounted upon a heavy sled, used in yarding logs by drum and cable. (P. C. F.)

LOG RULES AND TABLES OF CUBIC CONTENTS

TABLE I. — CLARK'S INTERNATIONAL LOG RULE[1]

Diameter in inches.	Length in feet.												
	8	9	10	11	12	13	14	15	16	17	18	19	20
	Contents in board feet.[2]												
6	10	10	10	15	15	15	20	20	20	25	25	30	30
7	15	15	15	20	20	25	25	30	30	35	35	40	45
8	20	20	25	25	30	35	35	40	45	45	50	55	60
9	25	30	30	35	40	45	50	50	55	60	65	70	75
10	30	35	40	45	50	55	60	65	70	75	85	90	95
11	40	45	50	55	65	70	75	80	90	95	105	110	115
12	50	55	65	70	75	85	90	100	105	115	125	130	140
13	60	65	75	85	90	100	110	120	130	140	145	155	165
14	70	80	90	100	110	120	130	140	150	160	175	185	195
15	80	90	105	115	125	140	150	160	175	185	200	215	225
16	95	105	120	130	145	160	170	185	200	215	230	245	260
17	105	120	135	150	165	180	195	210	225	245	260	275	295
18	120	135	155	170	185	205	220	240	255	275	295	310	330
19	135	155	175	190	210	230	250	270	290	310	330	350	370
20	150	170	195	215	235	255	275	300	320	345	365	390	410
21	170	190	215	235	260	285	305	330	355	380	405	430	455
22	185	210	235	260	285	315	340	365	390	420	445	475	500
23	205	230	260	285	315	345	370	400	430	460	490	520	550
24	225	255	285	315	345	375	405	440	470	500	535	565	600
25	245	275	310	345	375	410	445	475	510	545	580	615	650
26	265	300	335	370	405	445	480	520	555	595	630	670	705
27	290	325	365	405	440	480	520	560	600	640	680	725	765
28	310	350	395	435	475	520	560	605	645	690	735	780	825
29	335	380	425	470	510	560	605	650	695	740	790	835	885
30	360	405	455	500	550	600	645	695	745	795	845	895	950
31	385	435	485	540	590	640	695	745	800	850	905	960	1015
32	410	465	520	575	630	685	740	795	850	910	965	1025	1080
33	440	495	555	610	670	730	790	850	905	970	1030	1090	1150
34	470	530	590	650	715	775	840	900	965	1030	1095	1160	1225
35	495	560	625	690	755	825	890	955	1025	1095	1160	1230	1300
36	525	595	665	735	800	875	945	1015	1085	1160	1230	1305	1375
37	560	630	705	775	850	925	1000	1075	1150	1225	1300	1380	1445
38	590	665	745	820	895	975	1055	1135	1210	1295	1375	1455	1535
39	620	705	785	865	945	1030	1110	1195	1280	1365	1450	1535	1620
40	655	740	825	910	995	1085	1170	1260	1345	1435	1525	1615	1705
41	690	780	870	960	1050	1140	1230	1325	1415	1510	1605	1700	1795
42	725	820	915	1010	1100	1200	1295	1390	1490	1585	1685	1785	1885
43	760	860	960	1060	1155	1260	1360	1460	1560	1665	1770	1870	1975
44	800	900	1005	1110	1215	1320	1425	1530	1635	1745	1855	1960	2070
45	835	945	1055	1160	1270	1380	1490	1600	1715	1825	1940	2050	2165
46	875	990	1100	1215	1330	1445	1560	1675	1790	1910	2030	2145	2265
47	915	1035	1150	1270	1390	1510	1630	1750	1870	1995	2120	2240	2365
48	955	1080	1205	1325	1450	1575	1700	1830	1955	2085	2210	2340	2470

[1] By permission of Judson F. Clark.

[2] The contents are for logs sawed on a band saw cutting $\frac{1}{8}$-inch kerf. Correction factors for lumber cut with saws removing other kerfs are given on p. 110.

TABLE II. — SCRIBNER DECIMAL "C" LOG RULE[1]

FOR LOGS UP TO AND INCLUDING 32 FEET IN LENGTH

Diameter in inches.	Length in feet.													
	6	8	10	12	14	16	18	20	22	24	26	28	30	32
	Contents in board feet.													
6	0.5	0.5	1	1	1	2	2	2	3	3	3	4	4	5
7	0.5	1	1	2	2	3	3	3	4	4	4	5	5	6
8	1	1	2	2	2	3	3	3	4	4	5	6	6	7
9	1	2	3	3	3	4	4	4	5	6	6	7	8	9
10	2	3	3	3	4	6	6	7	8	9	9	10	11	12
11	2	3	4	4	5	7	8	8	9	10	11	12	13	14
12	3	4	5	6	7	8	9	10	11	12	13	14	15	16
13	4	5	6	7	8	10	11	12	13	15	16	17	18	19
14	4	6	7	9	10	11	13	14	16	17	19	20	21	23
15	5	7	9	11	12	14	16	18	20	21	23	25	27	28
16	6	8	10	12	14	16	18	20	22	24	26	28	30	32
17	7	9	12	14	16	18	21	23	25	28	30	32	35	37
18	8	11	13	16	19	21	24	27	29	32	35	37	40	43
19	9	12	15	18	21	24	27	30	33	36	39	42	45	48
20	11	14	17	21	24	28	31	35	38	42	45	49	52	56
21	12	15	19	23	27	30	34	38	42	46	49	53	57	61
22	13	17	21	25	29	33	38	42	46	50	54	58	63	67
23	14	19	23	28	33	38	42	47	52	57	61	66	71	75
24	15	21	25	30	35	40	45	50	55	61	66	71	76	81
25	17	23	29	34	40	46	52	57	63	69	75	80	86	92
26	19	25	31	37	44	50	56	62	69	75	82	88	94	100
27	21	27	34	41	48	55	62	68	75	82	89	96	103	110
28	22	29	36	44	51	58	65	73	80	87	95	102	109	116
29	23	31	38	46	53	61	68	76	84	91	99	107	114	122
30	25	33	41	49	57	66	74	82	90	99	107	115	123	131
31	27	36	44	53	62	71	80	89	98	106	115	124	133	142
32	28	37	46	55	64	74	83	92	101	110	120	129	138	147
33	29	39	49	59	69	78	88	98	108	118	127	137	147	157
34	30	40	50	60	70	80	90	100	110	120	130	140	150	160
35	33	44	55	66	77	88	98	109	120	131	142	153	164	175
36	35	46	58	69	81	92	104	115	127	138	150	161	173	185
37	39	51	64	77	90	103	116	129	142	154	167	180	193	206
38	40	54	67	80	93	107	120	133	147	160	174	187	200	214
39	42	56	70	84	98	112	126	140	154	168	182	196	210	224
40	45	60	75	90	105	120	135	150	166	181	196	211	226	241
41	48	64	79	95	111	127	143	159	175	191	207	223	238	254
42	50	67	84	101	117	134	151	168	185	201	218	235	252	269
43	52	70	87	105	122	140	157	174	192	209	227	244	262	279
44	56	74	93	111	129	148	166	185	204	222	241	259	278	296
45	57	76	95	114	133	152	171	190	209	228	247	266	286	304

[1] Taken from the National Forest Manual, U. S. Forest Service.

TABLE II. — *Continued.* SCRIBNER DECIMAL "C" LOG RULE

Diameter in inches.	Length in feet.													
	6	8	10	12	14	16	18	20	22	24	26	28	30	32
	Contents in board feet.													
46.......	59	79	99	119	139	159	178	198	218	238	258	278	297	317
47.......	62	83	104	124	145	166	186	207	228	248	269	290	310	331
48.......	65	86	108	130	151	173	194	216	238	260	281	302	324	346
49.......	67	90	112	135	157	180	202	225	247	270	292	314	337	359
50.......	70	94	117	140	164	187	211	234	257	281	304	328	351	374
51.......	73	97	122	146	170	195	219	243	268	292	315	341	365	389
52.......	76	101	127	152	177	202	228	253	278	304	329	354	380	405
53.......	79	105	132	158	184	210	237	263	289	316	341	368	395	421
54.......	82	109	137	164	191	218	246	273	300	328	355	382	410	437
55.......	85	113	142	170	198	227	255	283	312	340	368	397	425	453
56.......	88	118	147	176	206	235	264	294	323	353	382	411	441	470
57.......	91	122	152	183	213	244	274	304	335	365	396	426	457	487
58.......	95	126	158	189	221	252	284	315	347	379	410	442	473	505
59.......	98	131	163	196	229	261	294	327	359	392	425	457	490	523
60.......	101	135	169	203	237	270	304	338	372	406	439	473	507	541
61.......	105	140	175	210	245	280	315	350	385	420	455	490	525	560
62.......	108	145	181	217	253	289	325	362	398	434	470	506	542	579
63.......	112	149	187	224	261	299	336	373	411	448	485	523	560	597
64.......	116	154	193	232	270	309	348	387	425	464	503	541	580	619
65.......	119	159	199	239	279	319	358	398	438	478	518	558	597	637
66.......	123	164	206	247	288	329	370	412	453	494	535	576	617	659
67.......	127	170	212	254	297	339	381	423	466	508	550	593	635	677
68.......	131	175	219	262	306	350	393	437	480	524	568	611	655	699
69.......	135	180	226	271	316	361	406	452	497	542	587	632	677	723
70.......	139	186	232	279	325	372	419	465	512	558	605	651	698	744
71.......	144	192	240	287	335	383	430	478	526	574	622	670	717	765
72.......	148	197	247	296	345	395	444	493	543	592	641	691	740	789
73.......	152	203	254	305	356	406	457	508	559	610	661	712	762	813
74.......	157	209	261	314	366	418	471	523	576	628	680	733	785	837
75.......	161	215	269	323	377	430	484	538	592	646	700	754	807	861
76.......	166	221	277	332	387	443	498	553	609	664	719	775	830	885
77.......	171	228	285	341	398	455	511	568	625	682	739	796	852	909
78.......	176	234	293	351	410	468	527	585	644	702	761	819	878	936
79.......	180	240	301	361	421	481	541	602	662	722	782	842	902	963
80.......	185	247	309	371	432	494	556	618	680	742	804	866	927	989
81.......	190	254	317	381	444	508	572	635	699	762	826	889	953	1016
82.......	196	261	326	391	456	521	586	652	717	782	847	912	977	1043
83.......	201	268	335	401	468	535	601	668	735	802	869	936	1002	1069
84.......	206	275	343	412	481	549	618	687	755	824	893	961	1030	1099
85.......	210	281	351	421	491	561	631	702	772	842	912	982	1052	1123

TABLE II. — *Concluded.* SCRIBNER DECIMAL "C" LOG RULE

Diameter in inches.	Length in feet. 6	8	10	12	14	16	18	20	22	24	26	28	30	32
	Contents in board feet.													
86......	215	287	359	431	503	575	646	718	790	862	934	1006	1077	1149
87......	221	295	368	442	516	589	663	737	810	884	958	1031	1105	1179
88......	226	301	377	452	527	603	678	753	829	904	979	1055	1130	1205
89......	231	308	385	462	539	616	693	770	847	924	1001	1078	1155	1232
90......	236	315	393	472	551	629	708	787	865	944	1023	1101	1180	1259
91......	241	322	402	483	563	644	725	805	886	966	1047	1127	1208	1288
92......	246	329	411	493	575	657	739	822	904	986	1068	1150	1232	1315
93......	251	335	419	503	587	671	754	838	922	1006	1090	1174	1257	1341
94......	257	343	428	514	600	685	771	857	942	1028	1114	1199	1285	1371
95......	262	350	437	525	612	700	788	875	963	1050	1138	1225	1313	1400
96......	268	357	446	536	625	715	804	893	983	1072	1161	1251	1340	1429
97......	273	364	455	546	637	728	819	910	1001	1092	1183	1274	1365	1456
98......	278	371	464	557	650	743	835	928	1021	1114	1207	1300	1392	1485
99......	284	379	473	568	663	757	852	947	1041	1136	1231	1325	1420	1515
100......	289	386	482	579	675	772	869	965	1062	1158	1255	1351	1448	1544
101......	295	393	492	590	688	787	885	983	1082	1180	1278	1377	1475	1573
102......	301	401	502	602	702	803	903	1003	1104	1204	1304	1405	1505	1605
103......	307	409	512	614	716	819	921	1023	1126	1228	1330	1433	1535	1637
104......	313	417	522	626	730	835	939	1043	1148	1252	1356	1461	1565	1669
105......	319	425	532	638	744	851	957	1063	1170	1276	1382	1489	1595	1701
106......	325	433	542	650	758	867	975	1083	1192	1300	1408	1517	1625	1733
107......	331	442	553	663	773	884	995	1105	1216	1326	1437	1547	1658	1768
108......	337	450	563	675	788	900	1013	1125	1238	1350	1463	1575	1688	1800
109......	344	459	573	688	803	917	1032	1147	1261	1376	1491	1605	1720	1835
110......	350	467	583	700	817	933	1050	1167	1283	1400	1517	1633	1750	1867
111......	356	475	594	713	832	951	1069	1188	1307	1426	1545	1664	1782	1901
112......	362	483	604	725	846	967	1087	1208	1329	1450	1571	1692	1812	1933
113......	369	492	615	738	861	984	1107	1230	1353	1476	1599	1722	1845	1968
114......	375	501	626	751	876	1001	1126	1252	1377	1502	1627	1752	1877	2003
115......	382	509	637	764	891	1019	1146	1273	1401	1528	1655	1783	1910	2037
116......	389	519	648	778	908	1037	1167	1297	1426	1556	1686	1815	1945	2075
117......	396	528	660	792	924	1056	1188	1320	1452	1584	1716	1848	1980	2112
118......	403	537	672	806	940	1075	1209	1343	1478	1612	1746	1881	2015	2149
119......	410	547	683	820	957	1093	1230	1367	1503	1640	1777	1913	2050	2187
120......	417	556	695	834	973	1112	1251	1390	1529	1668	1807	1946	2085	2224

TABLE III. — DOYLE LOG RULE[1]

Length in feet.	Diameter in inches.																						
	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
	Contents in board feet.																							
8	2.0	4.5	8	12	18	24	32	40	50	60	72	84	98	112	128	144	162	180	200	220	242	264	288	312
9	2.3	5.1	9	14	20	28	36	46	56	68	81	95	110	127	144	163	182	203	225	248	272	297	324	352
10	2.5	5.6	10	16	23	31	40	50	62	75	90	106	122	141	160	181	202	226	250	276	302	330	360	391
11	2.8	6.2	11	17	25	34	44	55	69	83	99	116	135	155	176	199	223	248	275	303	334	363	396	430
12	3.0	6.8	12	19	27	37	48	61	75	91	108	127	147	169	192	217	243	271	300	331	363	397	432	469
13	3.3	7.3	13	20	29	40	52	66	81	98	117	137	159	183	208	235	263	293	325	358	393	430	468	508
14	3.5	7.9	14	22	32	43	56	71	88	106	126	148	171	197	224	253	283	313	350	386	423	463	504	547
15	3.8	8.4	15	23	34	46	60	76	94	113	135	158	184	211	240	271	303	336	375	413	458	496	540	586
16	4.0	9.0	16	25	36	49	64	81	100	121	144	169	196	225	256	289	324	359	400	441	484	530	576	625
17	4.3	9.6	17	27	38	52	68	86	106	128	153	180	208	239	272	307	344	383	425	469	514	563	612	664
18	4.5	10.1	18	28	41	55	72	91	112	136	162	190	220	253	288	325	364	406	450	496	544	596	648	703
19	4.8	10.7	19	30	43	58	76	96	119	143	171	201	233	267	304	343	384	429	475	524	575	630	684	742
20	5.0	11.3	20	31	46	61	80	101	125	151	180	211	245	280	320	361	404	452	500	551	605	661	720	782
21	5.3	11.8	21	33	48	64	84	106	131	158	189	222	257	295	336	379	425	473	525	579	635	693	756	820
22	5.5	12.4	22	34	50	67	88	111	137	166	198	232	269	309	352	397	445	496	550	606	665	726	792	860
23	5.8	12.9	23	36	52	70	92	116	144	174	207	243	282	323	368	415	465	519	575	634	696	760	828	898
24	6.0	13.5	24	37	54	74	96	122	150	181	216	253	294	338	384	433	486	541	600	661	726	794	864	938
25	6.3	14.0	25	39	56	77	100	127	156	189	225	264	306	351	400	451	506	562	625	689	756	827	900	977
26	6.5	14.6	26	41	59	80	104	132	163	196	234	275	318	366	416	470	526	586	650	717	786	860	936	1016
27	6.8	15.2	27	42	61	83	108	137	169	204	243	285	331	380	432	488	546	606	675	744	817	893	972	1055
28	7.0	15.8	28	44	63	86	112	142	175	212	252	296	343	394	448	506	566	626	700	772	847	926	1008	1094
29	7.3	16.3	29	45	65	89	116	147	182	219	261	306	355	408	464	524	586	649	725	799	877	959	1044	1133
30	7.5	16.8	30	47	68	92	120	152	188	226	270	317	367	421	480	542	606	672	750	827	907	992	1080	1172
31	7.8	17.4	31	48	70	95	124	157	193	234	279	327	380	436	496	560	627	695	775	854	938	1026	1116	1211
32	8.0	18.0	32	50	72	98	128	162	200	242	288	338	392	450	512	578	648	718	800	882	968	1060	1152	1250
33	8.3	18.5	33	52	74	101	132	167	206	249	297	349	404	464	528	596	668	742	825	910	998	1093	1188	1289
34	8.5	19.1	34	53	77	104	136	172	212	256	306	359	416	478	544	614	688	766	850	937	1028	1126	1224	1328
35	8.8	19.7	35	55	79	107	140	177	219	265	315	370	429	492	560	632	708	789	875	965	1059	1159	1260	1367
36	9.0	20.3	36	56	81	110	144	182	225	272	324	380	441	506	576	650	729	812	900	992	1089	1192	1296	1406
37	9.3	20.8	37	58	83	113	148	187	231	280	333	391	453	520	592	668	749	835	925	1020	1119	1223	1332	1445
38	9.5	21.4	38	59	85	116	152	192	237	287	342	401	465	534	608	686	769	857	950	1047	1149	1256	1368	1484
39	9.8	21.9	39	61	88	119	156	197	243	295	351	412	478	548	624	704	790	880	975	1075	1180	1289	1404	1523
40	10.0	22.5	40	62	90	122	160	202	250	302	360	422	490	562	640	722	810	903	1000	1102	1210	1322	1440	1562

[1] From the Woodsman's Handbook, Bul. 36, U. S. Forest Service.

TABLE III. — *Continued.* DOYLE LOG RULE

Length in feet.	Diameter in inches.														
	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
	Contents in board feet.														
8	338	364	392	420	450	480	512	544	578	612	648	684	722	761	800
9	380	410	441	473	506	540	576	613	650	689	729	770	812	856	900
10	422	456	490	526	562	601	640	681	723	765	810	856	902	951	1000
11	465	502	539	578	619	661	704	749	795	842	891	941	993	1046	1100
12	507	547	588	631	675	721	768	817	867	910	972	1027	1083	1141	1200
13	549	592	637	683	731	781	832	884	939	996	1053	1112	1173	1237	1300
14	591	638	686	736	787	841	896	953	1011	1070	1134	1198	1264	1331	1400
15	633	683	735	789	844	901	960	1021	1083	1149	1215	1284	1354	1426	1500
16	676	729	784	841	900	961	1024	1089	1156	1225	1296	1369	1444	1521	1600
17	718	774	833	894	956	1021	1088	1157	1228	1302	1377	1455	1534	1616	1700
18	761	820	882	946	1012	1081	1152	1225	1300	1379	1458	1540	1625	1711	1800
19	803	865	931	999	1069	1141	1216	1293	1372	1455	1539	1626	1715	1806	1900
20	845	912	980	1051	1125	1202	1280	1361	1446	1530	1620	1711	1805	1902	2000
21	887	957	1029	1104	1181	1261	1344	1430	1518	1607	1701	1797	1895	1997	2100
22	930	1004	1078	1156	1237	1322	1408	1497	1590	1684	1782	1882	1986	2091	2200
23	972	1049	1127	1209	1293	1381	1472	1566	1662	1761	1863	1968	2076	2187	2300
24	1014	1094	1176	1262	1350	1442	1536	1634	1734	1838	1944	2053	2166	2282	2400
25	1056	1139	1225	1314	1406	1501	1600	1702	1806	1915	2025	2139	2256	2376	2500
26	1098	1184	1274	1367	1462	1562	1664	1768	1878	1992	2106	2225	2346	2472	2600
27	1140	1230	1323	1420	1518	1622	1728	1838	1950	2067	2187	2310	2437	2567	2700
28	1182	1276	1372	1472	1575	1682	1792	1906	2022	2144	2268	2396	2527	2662	2800
29	1224	1321	1421	1524	1631	1742	1856	1974	2095	2221	2349	2481	2617	2756	2900
30	1266	1366	1470	1577	1687	1802	1920	2042	2166	2298	2430	2567	2708	2852	3000
31	1309	1412	1519	1629	1743	1862	1984	2110	2239	2373	2511	2652	2798	2946	3100
32	1352	1458	1568	1682	1800	1922	2048	2178	2312	2450	2592	2738	2888	3042	3200
33	1394	1503	1617	1735	1856	1982	2112	2246	2386	2526	2673	2824	2978	3137	3300
34	1436	1548	1666	1787	1912	2042	2176	2314	2456	2604	2754	2909	3068	3232	3400
35	1479	1594	1715	1840	1968	2102	2240	2383	2529	2681	2835	2995	3159	3327	3500
36	1522	1640	1764	1892	2025	2162	2304	2450	2601	2756	2916	3080	3249	3423	3600
37	1563	1686	1813	1945	2081	2222	2368	2518	2673	2833	2997	3166	3339	3517	3700
38	1606	1731	1862	1998	2138	2282	2432	2586	2745	2909	3078	3251	3429	3612	3800
39	1648	1778	1911	2050	2194	2342	2496	2654	2818	2986	3159	3337	3520	3707	3900
40	1690	1822	1960	2102	2250	2402	2560	2722	2890	3062	3240	3423	3610	3802	4000

TABLE IV. — THE NINETEEN-INCH STANDARD RULE[1]
BASED ON THIRTEEN-FOOT LOGS

Diameter in inches.	Length in feet.																				
	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
	Contents in standards.																				
4	0.03	0.03	0.04	0.04	0.04	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.08	0.08	0.08	0.09	0.09	0.09
5	0.05	0.06	0.06	0.07	0.08	0.08	0.09	0.09	0.10	0.10	0.11	0.11	0.12	0.12	0.13	0.13	0.14	0.15	0.15	0.16	0.16
6	0.08	0.08	0.09	0.10	0.11	0.12	0.12	0.13	0.14	0.15	0.15	0.16	0.17	0.18	0.18	0.19	0.20	0.21	0.22	0.22	0.23
7	0.11	0.12	0.13	0.14	0.15	0.16	0.17	0.18	0.19	0.20	0.22	0.23	0.24	0.25	0.26	0.27	0.28	0.29	0.31	0.31	0.32
8	0.14	0.15	0.17	0.18	0.19	0.21	0.22	0.24	0.25	0.26	0.28	0.29	0.31	0.32	0.33	0.35	0.36	0.37	0.39	0.40	0.42
9	0.17	0.19	0.20	0.22	0.24	0.25	0.27	0.29	0.30	0.32	0.34	0.36	0.37	0.39	0.41	0.42	0.44	0.46	0.49	0.49	0.51
10	0.21	0.23	0.26	0.28	0.30	0.32	0.34	0.36	0.38	0.40	0.43	0.45	0.47	0.49	0.51	0.53	0.55	0.58	0.60	0.62	0.64
11	0.26	0.28	0.31	0.34	0.36	0.39	0.41	0.44	0.46	0.49	0.52	0.54	0.57	0.59	0.62	0.65	0.67	0.70	0.72	0.75	0.77
12	0.31	0.34	0.37	0.40	0.43	0.46	0.49	0.52	0.55	0.58	0.61	0.64	0.67	0.71	0.74	0.77	0.80	0.83	0.86	0.89	0.92
13	0.36	0.40	0.43	0.47	0.50	0.54	0.58	0.61	0.65	0.68	0.72	0.76	0.79	0.83	0.86	0.90	0.94	0.97	1.01	1.04	1.08
14	0.42	0.46	0.50	0.54	0.58	0.63	0.67	0.71	0.75	0.79	0.84	0.88	0.92	0.96	1.00	1.04	1.09	1.13	1.17	1.21	1.25
15	0.48	0.53	0.58	0.62	0.67	0.72	0.77	0.81	0.86	0.91	0.96	1.01	1.05	1.10	1.15	1.20	1.25	1.29	1.34	1.39	1.44
16	0.55	0.60	0.65	0.71	0.76	0.82	0.87	0.93	0.98	1.04	1.09	1.15	1.20	1.25	1.31	1.36	1.42	1.47	1.53	1.58	1.64
17	0.62	0.68	0.74	0.80	0.86	0.92	0.99	1.05	1.11	1.17	1.23	1.29	1.35	1.42	1.48	1.54	1.60	1.66	1.72	1.79	1.85
18	0.69	0.76	0.83	0.90	0.97	1.04	1.10	1.17	1.24	1.31	1.38	1.45	1.52	1.59	1.66	1.73	1.80	1.86	1.93	2.00	2.07
19	0.77	0.85	0.92	1.00	1.08	1.15	1.23	1.31	1.38	1.46	1.54	1.62	1.69	1.77	1.85	1.92	2.00	2.08	2.15	2.23	2.31
20	0.85	0.94	1.02	1.11	1.19	1.28	1.36	1.45	1.53	1.62	1.70	1.79	1.88	1.96	2.05	2.13	2.23	2.30	2.39	2.47	2.56
21	0.94	1.03	1.13	1.22	1.32	1.41	1.50	1.60	1.69	1.79	1.88	1.97	2.07	2.16	2.26	2.35	2.44	2.54	2.63	2.73	2.82
22	1.03	1.13	1.24	1.34	1.44	1.55	1.65	1.75	1.86	1.96	2.06	2.17	2.27	2.37	2.48	2.58	2.68	2.78	2.89	2.99	3.09
23	1.13	1.24	1.35	1.47	1.58	1.69	1.80	1.92	2.03	2.14	2.25	2.37	2.48	2.59	2.71	2.82	2.93	3.04	3.16	3.27	3.38
24	1.23	1.35	1.47	1.60	1.72	1.84	1.96	2.09	2.21	2.33	2.46	2.58	2.70	2.82	2.95	3.07	3.19	3.31	3.44	3.56	3.68
25	1.33	1.46	1.60	1.73	1.86	2.00	2.13	2.26	2.40	2.53	2.66	2.80	2.93	3.06	3.20	3.33	3.46	3.60	3.73	3.86	4.00
26	1.44	1.58	1.73	1.87	2.02	2.16	2.30	2.45	2.59	2.74	2.88	3.02	3.17	3.31	3.46	3.60	3.75	3.89	4.03	4.18	4.32
27	1.55	1.71	1.86	2.02	2.17	2.33	2.49	2.64	2.80	2.95	3.11	3.26	3.42	3.57	3.73	3.88	4.04	4.19	4.35	4.51	4.66
28	1.67	1.84	2.00	2.17	2.34	2.51	2.67	2.84	3.01	3.17	3.34	3.51	3.68	3.84	4.01	4.18	4.34	4.51	4.68	4.84	5.01
29	1.79	1.97	2.15	2.33	2.51	2.69	2.87	3.05	3.23	3.40	3.58	3.76	3.94	4.12	4.30	4.48	4.66	4.84	5.02	5.20	5.38
30	1.92	2.11	2.30	2.49	2.68	2.88	3.07	3.26	3.45	3.64	3.84	4.03	4.22	4.41	4.60	4.79	4.99	5.18	5.37	5.56	5.75
31	2.05	2.25	2.46	2.66	2.87	3.07	3.28	3.48	3.69	3.89	4.10	4.30	4.51	4.71	4.91	5.12	5.32	5.53	5.73	5.94	6.14
32	2.18	2.40	2.62	2.84	3.05	3.27	3.49	3.71	3.93	4.15	4.36	4.58	4.80	5.02	5.24	5.45	5.67	5.89	6.11	6.33	6.55
33	2.32	2.55	2.78	3.02	3.25	3.48	3.71	3.94	4.18	4.41	4.64	4.87	5.10	5.34	5.57	5.80	6.03	6.27	6.50	6.73	6.96
34	2.46	2.71	2.96	3.20	3.45	3.69	3.94	4.19	4.43	4.68	4.93	5.17	5.42	5.66	5.91	6.16	6.40	6.65	6.90	7.14	7.39
35	2.61	2.87	3.13	3.39	3.65	3.92	4.18	4.44	4.70	4.96	5.22	5.48	5.74	6.00	6.26	6.53	6.79	7.05	7.31	7.57	7.83
36	2.76	3.04	3.31	3.59	3.87	4.14	4.42	4.69	4.97	5.25	5.52	5.80	6.08	6.35	6.63	6.90	7.18	7.46	7.73	8.01	8.28

[1] From the Woodsman's Handbook.

TABLE V. — THE NEW HAMPSHIRE OR BLODGETT LOG RULE[1]

Diameter in inches.	Length in feet.															
	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
	Contents in board feet.															
4	5	6	7	9	10	10	11	13	14	15	16	17	18	19	20	21
5	8	10	11	13	15	17	18	20	21	23	24	26	28	30	31	33
6	12	14	16	19	22	24	26	29	31	34	37	38	41	43	46	49
7	16	19	22	26	29	33	36	39	43	46	50	52	56	59	63	66
8	22	26	30	35	39	43	48	52	57	61	65	70	74	78	83	87
9	27	33	38	43	50	54	60	65	70	77	81	87	93	98	103	108
10	34	41	48	54	61	68	75	82	88	95	102	109	116	123	129	136
11	41	50	57	66	74	82	90	98	107	115	123	131	140	148	157	164
12	49	58	69	78	88	97	108	117	127	137	147	157	166	177	186	196
13	57	70	80	92	103	115	126	137	149	161	172	183	195	207	218	230
14	66	80	93	106	120	133	146	160	174	186	200	213	226	240	253	266
15	77	91	107	123	137	153	168	183	199	214	230	244	260	275	290	305
16	87	104	122	139	157	174	191	209	226	243	261	278	296	313	330	348
17	98	117	137	157	177	197	216	236	255	275	295	314	334	353	373	392
18	110	132	154	176	198	220	242	264	284	308	330	352	374	397	418	440
19	123	148	171	197	221	245	270	294	319	343	368	392	417	442	466	490
20	136	163	190	217	244	271	299	326	353	380	408	435	462	490	517	543
21	150	180	210	240	270	300	330	360	390	420	450	480	510	540	570	600
22	165	197	230	262	296	329	363	395	427	460	493	526	559	592	624	657
23	180	216	251	287	323	359	396	431	467	503	539	575	610	647	683	718
24	196	235	274	313	352	391	430	469	509	548	587	626	665	704	739	783
25	212	255	297	339	383	424	467	509	551	595	637	679	722	764	807	849
26	230	276	322	367	413	459	505	551	597	643	689	735	781	827	872	918
27	248	297	347	397	446	496	544	594	643	693	743	792	842	891	941	990
28	266	319	373	426	479	533	586	639	692	745	799	852	905	958	1012	1065
29	285	343	400	457	514	572	629	685	743	800	865	914	971	1029	1085	1143
30	300	367	428	489	550	611	672	734	795	856	917	978	1039	1101	1162	1223
31	326	391	457	514	588	653	718	783	849	914	979	1044	1110	1175	1240	...
32	348	417	487	557	626	696	765	835	904	974	1043	1113	1183	1252	1322	...
33	370	443	517	592	666	740	814	888	962	1036	1110	1183	1257	1331	...	...
34	392	471	549	628	707	785	863	943	1021	1099	1178	1257	1335	1414	...	...
35	416	499	583	666	749	832	916	998	1082	1165	1251	1331	1415	...	...	...
36	440	528	617	704	792	880	969	1057	1144	1232	1321	1409	1497	...	...	...
37	465	558	651	744	837	930	1023	1116	1209	1302	1395	1488	...	...	...	...
38	490	589	687	785	883	981	1079	1177	1275	1374	1471	1569	...	...	...	...
39	517	620	723	827	930	1034	1137	1240	1343	1446	1550	...	...	...	...	...
40	543	652	761	870	978	1087	1196	1304	1413	1522	1630	...	...	...	...	...
41	571	685	799	914	1028	1142	1257	1370	1484	1598	...	...	...	...	...	...
42	599	719	839	959	1078	1198	1318	1438	1557	1678	...	...	...	...	...	...
43	626	751	877	1002	1126	1251	1377	1502	1627	...	...	...	...	...	...	...
44	657	790	921	1052	1183	1315	1447	1578	1709	...	...	...	...	...	...	...
45	688	826	963	1101	1238	1376	1513	1650	...	...	...	...	...	...	...	...
46	718	863	1006	1149	1294	1437	1581	1725	...	...	...	...	...	...	...	...
47	742	900	1050	1201	1350	1501	1650	...	...	...	...	...	...	...	...	...
48	783	939	1096	1252	1409	1565	1722	...	...	...	...	...	...	...	...	...

[1] From the Woodman's Handbook.

TABLE VI. — VOLUME OF SOLID WOOD PER 128 CUBIC FEET OF SPACE[1]

Length of stick.	1st class, small diameter over 5.5 inches.	2nd class, small diameter 2.5 to 5.5 inches.	3rd class, small diameter 1.0 to 2.5 inches.	1st and 2nd classes, mixed.	2nd and 3rd classes, mixed.
Inches.	Cubic feet.				
10	91.98	85.40	65.70	88.69	75.55
12	91.80	85.25	65.69	88.53	75.47
14	91.67	85.10	65.65	88.39	75.38
16	91.50	84.95	65.60	88.23	75.28
18	91.37	84.80	65.55	88.09	75.18
20	91.20	84.67	65.50	87.94	75.09
22	91.05	84.50	65.40	87.78	74.95
24	90.90	84.35	65.32	87.63	74.84
26	90.75	84.20	65.23	87.48	74.72
28	90.60	84.05	65.12	87.33	74.59
30	90.45	83.90	65.00	87.18	74.45
Feet					
3	89.98	83.40	64.60	86.69	74.00
4	88.92	82.42	63.62	85.67	73.02
5	87.75	81.30	62.60	84.53	71.95
6	86.45	80.00	61.60	83.23	70.80
7	85.38	78.82	60.55	82.10	69.69
8	83.75	77.20	59.40	80.48	68.30
9	82.40	75.80	58.20	79.10	67.00
10	81.00	74.30	56.90	77.65	65.60
11	79.60	72.80	55.60	76.20	64.20
12	78.05	71.20	54.25	74.63	62.73
13	76.45	69.60	52.90	73.03	61.25
14	74.85	67.95	51.50	71.40	59.73

[1] From Factors Influencing the Volume of Solid Wood in the Cord, by Raphael Zon, Forestry Quarterly, Vol. I, p. 132.

TABLE VII. — VOLUME OF SOLID WOOD IN STACKS[1]

(4 feet high, 8 feet long, and of varying widths)

Length of stick.	1st class, small diameter over 5.5 inches.	2nd class, small diameter 2.5 to 5.5 inches.	3rd class, small diameter 1.0 to 2.5 inches.	1st and 2nd classes, mixed.	2nd and 3rd classes, mixed.
Inches.	Cubic feet.				
10	19.50	17.50	14.00	18.50	15.75
12	23.50	21.00	16.00	22.25	18.50
14	27.32	24.50	19.00	25.91	21.75
16	31.00	28.50	21.50	29.75	25.00
18	35.00	32.00	24.30	33 50	28.15
20	37.50	35.00	27.00	36.25	31.00
22	42.20	39.00	30.00	40.60	34.50
24	46.02	42.00	32.70	44.01	37.35
26	50.00	46.00	35.20	48.00	40.60
28	53.21	49.00	38.00	51.11	43.50
30	57.00	53.00	41.00	55.00	47.00
Feet					
3	68.50	63.00	50.00	65.75	56.50
4	88.92	82.42	63.62	85.67	73.02
5	108.50	101.50	78.00	105.00	89.75
6	128.50	120.00	92.30	124.25	106.15
7	149.55	138.05	106.41	143.80	122.23
8	170.00	165.00	119.90	167.50	142.45
9	190.00	175.00	133.50	182.50	154.25
10	211.00	193.00	147.50	201.00	170.25
11	230.00	210.50	161.20	220.25	185.85
12	250.00	228.00	175.00	239.00	201.50
13	269.00	245.50	189.00	257.25	217.25
14	287.50	262.50	203.00	275.00	232.75

[1] From Factors Influencing the Volume of Solid Wood in a Cord, by Raphael Zon, Forestry Quarterly, Vol. I, p. 133.

TABLE VIII. — STACKED CUBIC FEET IN LOGS OF GIVEN DIMENSIONS, 128 MAKE A CORD[1]

(True to nearest tenth up to 10 cubic feet, above that to nearest foot)

Length, in feet.	Diameter at middle, inches.																	
	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
4	0.2	0.4	0.7	1.0	1.4	1.8	2.3	2.8	3.4	4.0	4.7	5.4	6.2	7.1	8	9	10	11
8	0.5	0.9	1.4	2.0	2.7	3.5	4.5	5.5	6.7	8.0	9.4	11	12	14	16	18	20	22
10	0.6	1.1	1.7	2.5	3.4	4.4	5.6	6.9	8.4	10	12	14	16	18	20	22	25	28
12	0.7	1.3	2.1	3.0	4.1	5.3	6.8	8.3	10	12	14	16	19	21	24	27	30	33
13	0.8	1.4	2.2	3.2	4.4	5.8	7.3	9	11	13	15	18	20	23	26	29	33	36
16	1.0	1.8	2.8	4.0	5.5	7.1	9	11	13	16	19	22	25	28	32	36	40	44
20	...	2.2	3.5	5.0	6.8	8.9	11	14	17	20	23	27	31	36	40	45	50	56
21	...	2.3	3.6	5.2	7.2	9.3	12	15	18	21	25	29	33	37	42	47	52	59
22	...	2.4	3.8	5.5	7.5	9.8	12	15	18	22	26	30	34	39	44	49	55	61
23	...	2.6	4.0	5.8	7.8	10	13	16	19	23	27	31	36	41	46	52	58	64
24	...	2.7	4.2	6.0	8.2	11	13	17	20	24	28	33	38	43	48	54	60	67
25	...	2.8	4.3	6.2	8.5	11	14	17	21	25	29	34	39	44	50	56	63	70
26	...	2.9	4.5	6.5	8.8	11	15	18	22	26	31	35	41	46	52	59	65	73
27	...	3.0	4.7	6.8	9.2	12	15	19	23	27	32	37	42	48	54	61	68	75
28	...	...	4.8	7.0	9.5	12	16	19	23	28	33	38	44	50	56	63	70	78
29	...	...	5.0	7.2	9.9	13	16	20	24	29	34	39	45	52	58	65	73	81
30	...	...	5.2	7.5	10	13	17	21	25	30	35	41	47	53	60	67	75	83
31	...	...	....	7.8	11	14	17	22	26	31	36	42	48	55	62	70	78	86
32	...	...	....	8.0	11	14	18	22	27	32	38	44	50	57	64	72	80	89
33	...	...	....	8.2	11	15	19	23	28	33	39	45	51	59	66	74	83	92
34	...	...	....	8.5	12	15	19	24	29	34	40	46	53	60	68	76	85	94
35	...	...	....	8.8	12	16	20	24	29	35	41	47	55	62	70	79	87	97
36	...	...	....	9.0	12	16	20	25	30	36	42	48	56	64	72	81	90	100
37	...	...	....	9.2	13	16	21	26	31	37	43	50	58	66	74	83	93	103
38	...	...	....	9.5	13	17	21	26	32	38	45	52	59	68	76	86	95	105
39	...	...	....	9.8	13	17	22	27	33	39	46	53	61	69	78	88	98	108
40	...	...	....	10.0	14	18	23	28	34	40	47	54	62	71	80	90	100	111

[1] From Manual for Northern Woodsmen, by Austin Cary.

LOG GRADING RULES

HARDWOOD LOG GRADING RULES

(Nashville (Tenn.) Lumbermen's Association)

"Logs shall be graded as follows and designated as No. 1, No. 2, No. 3, No. 4, No. 5 and No. 6.

"No. 1 logs shall be 30 inches and up in diameter, fresh cut, green, straight and free from knots, windshakes and other defects.

"No. 2 logs shall be 27 to 30 inches in diameter inclusive, fresh cut, green, straight and free from knots, windshakes and other defects, except that this grade may take logs 30 inches and up in diameter with one to three small solid knots not exceeding 3 inches in diameter.

"No. 3 logs shall be 24 to 26 inches in diameter inclusive, fresh cut, green, straight and free from knots, windshakes and other defects, except that this grade may take logs 27 inches and up in diameter with one to three small solid knots not exceeding 3 inches in diameter.

"No. 4 logs shall be 20 to 23 inches in diameter inclusive, fresh cut, green, straight and free from knots, windshakes and other defects, except that this grade may take logs 24 inches and up in diameter with one to three small solid knots not exceeding 3 inches in diameter.

"No. 5 logs shall be 15 to 18 inches in diameter inclusive, fresh cut, green, and free from knots, windshakes and other defects, except that this grade may take logs 20 inches and up in diameter with one to three small solid knots not exceeding 3 inches in diameter.

"No. 6 logs shall be 12 to 14 inches in diameter inclusive, fresh cut, green, straight and free from knots, windshakes and other defects, except that this grade may take logs 15 inches and up in diameter with one to three small solid knots not exceeding 3 inches in diameter.

"All logs shall be cut full length.

"The following rules shall govern all measurements for defects.

"For a hollow log two-thirds of the diameter of the hollow in inches, shall be deducted from the diameter of the log and the hollow shall be measured the long way.

"Old logs shall have the following deductions made from contents: 2 inches for logs that have been held over one season, or that show sound discolored sap; 4 inches for logs older than one season, or that show rotten, or doty sap. Logs that show worm holes below sap line shall be classed as No. 6.

"All logs shall be measured at both ends. When there is a variation of one inch in the diameter, the least end shall be taken as the measurement of the log; if a variation of 2 inches, the number of inches shall be divided; if 3 inches the number of inches shall be divided as if only 2 inches; if 4 inches, the diameter shall be divided, but if the difference exceeds 4 inches it shall be divided as if only 4 inches.

" 'Edged' logs shall be measured the flat way.

"All crotch, or forked logs shall be cut off sufficient to clear the crotch or fork.

"All crooked logs shall be classed as No. 6, unless sufficient deductions are made for straightening.

"*Ash Logs.* — The same grading for defects shall apply to ash logs as applies to other logs, but ash logs shall be of the following sizes: No. 1, 24 inches and up in diameter; No. 2, 20 to 23 inches inclusive in diameter; No. 3, 18- and 19-inch logs; No. 4, 16- and 17-inch logs; No. 5, 15-inch logs; No. 6, 12-, 13- and 14-inch logs.

"*Linn, buckeye, hickory, gum, sycamore, beech, maple, butternut, pine and hackberry logs.* —

"No. 1 shall be 24 inches and up in diameter, fresh cut, green, straight and free from knots, windshakes and other defects.

"No. 2 shall be 20 to 23 inches in diameter inclusive, fresh cut, green, straight and free from knots, windshakes and other defects; except that this grade may take logs 24 inches and up in diameter with one to three small solid knots not exceeding 3 inches in diameter.

"No. 3 shall be 15 to 19 inches in diameter inclusive, fresh cut, green, straight and free from knots, windshakes and other defects; except that this grade may take logs 20 inches and up in diameter with one to three small solid knots not exceeding 3 inches in diameter.

"*Walnut Logs.* — Walnut logs shall be subject to special agreement between buyer and seller as to size and grading. No piece of timber will be considered a saw log, or will be measured as such, that is smaller in diameter than 12 inches.

"*Spikes.* — Seller of logs will be held responsible for damage resulting from spikes, or pieces of iron in logs.

"*Brands.* — All logs should be branded before being brought to market. Defacing, or changing of brands on logs, subjects perpetrator to prosecution."

DOUGLAS FIR LOG GRADING RULES

(Columbia River Log Scaling and Grading Bureau)

NO. 1 LOGS

"No. 1 logs shall be 30 inches or over in diameter inside the bark at the small end, reasonably straight grained, and not less than 16 feet long; and shall be logs which in the judgment of the scaler will contain at least 50 per cent of their scaled contents in lumber in the grades of No. 1 and No. 2 Clear lumber.

"In a general way it may be said that a pitch ring is not a serious grade defect in a No. 1 log, provided its location and size does not prevent the log cutting the requisite amount of Clears. The same applies to rot. Pitch pockets, seams, knots, etc., are defects which impair the grade in proportion to their effect on the amount of Clears the log contains. A No. 1 log will admit a few small knots, but must be surface clear for at least four-fifths its length; a few pitch pockets, as permitted in the grades of clear lumber, but no combination of defects which will prevent the required percentage of Clears.

NO. 2 LOGS

"No. 2 logs shall be 16 inches or over in diameter inside the bark at the small end; not less than 16 feet long, and having defects which prevent its grading No. 1, but which will in the judgment of the scaler be suitable for the manufacture of lumber principally in grades of 'merchantable' and better.

NO. 3 LOGS

"No. 3 logs shall be 12 inches or over in diameter inside the bark at the small end; not less than 16 feet long; having defects which prevent its grading No. 2 and shall in the judgment of the scaler be suitable for the manufacture of the inferior grades of lumber.

CULL LOGS

"Cull logs shall be any logs which do not contain 50 per cent of sound lumber.

"All logs to be scaled by the Spalding Rule."

"*Note.* — The various lumber tallies we have had of graded yellow fir rafts have shown that, figuring

No. 1 logs to contain 50 per cent of Clears,
No. 2 logs to contain 25 per cent of Clears,
No. 3 logs to contain no Clears,

there is a substantial overrun in the Clears obtained.

"*Note.* — There are defects characteristic of logs from certain localities for which it is impossible to make rigid rules."

WAGE LISTS

	Rate per day, exclusive of board.
Power logging:	
Yarding hook tenders	$3.50 to $4.00
Rigging slingers	2.50 to 2.75
Yarding engineers	3.50
Yarding firemen	2.25 to 2.75
Wood buckers	2.00 to 2.50
Chasers	2.00 to 2.75
Signal men	1.75 to 2.25
Spool tenders	2.50
Choker men	2.50
Head loaders	2.50 to 3.25
Locomotive firemen	2.50 to 3.00
Boom men	2.50
Railroad graders	1.75 to 2.00
Section men	1.75 to 2.00
Landing builders	2.25
Flunkies	2.25
Second loaders	2.50
Knotters	2.50
Swampers	1.75 to 2.25
Buckers	2.50
Head fallers	2.50
Second fallers	2.25 to 2.50
Undercutters	2.25
Road engineers	3.50
Brakemen	2.50 to 3.00
Locomotive engineers	4.00
Pump men	2.25
Night watchman	2.00 to 3.00
Blacksmith's helper	2.25 to 2.50
Bull cook	2.25
Blacksmith	2.50
	Rate per month, inclusive of board.
Flunkey	$35.00 to $40.00
Cook, 18 to 40 men	65.00 to 90.00
Cook, 40 men and over	75.00 to 125.00
Bull cook	30.00 to 40.00
Blacksmith	75.00 to 100.00
	Rate per month, exclusive of board.
Locomotive engineer	$100.00 to $125.00
Board per day	.75
Board per week	5.00

MONTANA AND IDAHO.—*Continued*

	Rate per day, exclusive of board.
Animal logging:	
Foreman	$3.50
Stableman	2.50
Blacksmith	$2.50 to 4.00
Handy man	2.25 to 4.00
Filer	2.50 to 3.25
Bull cook	2.00
Scaler	2.25 to 3.50
Teamster, hookman and sawyer	2.50 to 3.00
Swamper and common labor	1.75 to 2.50
Board per week	5.00 to 5.25
	Rate per month, inclusive of board.
Foreman	$75.00 to $125.00
Cook, furnish helper	65.00 to 75.00
Stableman	35.00 to 65.00
Blacksmith	65.00 to 75.00
Handy man	45.00 to 50.00
Filer	50.00
Flunkey	30.00 to 50.00
Bull cook	30.00 to 50.00
Clerk	45.00 to 75.00
Scaler	65.00 to 75.00

LAKE STATES, HEMLOCK AND HARDWOOD OPERATIONS, 1911–1912

	Rate per month, including board.
Chore boy	$26.00
Swamper	26.00
Roadman	37.00
Cookee	29.00
Sawyer	30.00
Hookman	31.00
Teamster	31.00
Barnman	32.00
Top loader	35.00
Blacksmith	56.00
Cook	65.00
Engineer	73.00

SOUTHERN PINE REGION, TEXAS, 1911

Power (cableway) logging:	Rate per day, exclusive of board.
Foreman	$2.25
Skidder leverman	4.00
Loading leverman	2.75
Top loader	2.25
Ground loader	2.00
Fireman	1.75
Tong hooker	1.50
Tong unhooker	2.00
Helper	1.50
Rigging slinger	3.00
Helper	2.00
Run cutter	1.75
Wood cutter and hauler	1.50
Night watchman	1.75

ARKANSAS, 1912

Animal logging:	Rate per day, exclusive of board.
Sawyer	$1.90 to $2.25
Teamster	1.90 to 2.00
Ox driver	2.10
Swamper	1.90
Loading engineer	3.50 to 4.00
Top loader	2.25
Ground loader	1.90
Foreman steel crew	3.60
Steel crew spiker	1.65
Steel crew labor	1.60
Foreman, cutting right-of-way	2.25
Right-of-way labor	1.65
Locomotive engineer	3.00
Locomotive fireman	1.75
Scaler	2.25
Filer	3.00
Barnman	1.90 to 2.10
Blacksmith	2.25
	Rate per month, exclusive of board
Camp foreman	$150.00
Team boss	85.00

CYPRESS REGION, LOUISIANA, 1910

Cableway skidder operation:	Rate per day, exclusive of board.
Skidder leverman	$3.50
Head rigger	3.50
Rigging helper	1.75
Skidder fireman	1.50 to 2.00
Tong hooker	2.25
Helper	1.75

LOUISIANA. — *Continued*

	Rate per day, exclusive of board.
Cypress logging, cableway skidder operation :	
Tong unhooker	$1.50
Run cutter	2.00
Signal man	1.50
Loading leverman	2.75
Top loader	2.25
Ground loader	1.75 to 2.00
Slack puller	1.50

VERMONT, 1912

	Rate per month, including board.
Teamster, 2 horses	$35.00 to $38.00
Teamster, 4 horses on sled hauls	40.00 to 45.00
Head chopper	35.00 to 38.00
Cant-dog man	35.00 to 38.00
	Rate per day, including board.
Cook	$1.50 to $2.25

PROVINCE OF ONTARIO, CANADA, 1911–1912

	Rate per month, including board.
Sawyer	$30.00
Teamster	32.00
Roller	32.00
Sender	30.00
Swamper	26.00 to 28.00
Notcher	32.00
Top loader	32.00
Tailer	28.00
Scaler	60.00

PACIFIC COAST, 1912

	Rate, exclusive of board.
Yarding:	
Crew boss	$125.00 per month
Head faller	3.50 per day
Second faller	3.25 " "
Bucker	$3.25 to 3.75 " "
Hook tender	5.00 " "
Rigging slinger	3.50 " "

PACIFIC COAST. — *Continued*

	Rate, exclusive of board.
Yarding:	
Choker man	$3.00 to $3.25 per day
Chaser	3.25 " "
Signalman	2.50 " "
Head loader	4.50 to 5.00 " "
Second loader	3.50 " "
Engineer	3.50 " "
Fireman	2.75 " "
Wood bucker	2.75 " "
Swamper	2.50 " "
Sniper	3.00 " "
Knotter	2.75 " "
Barker	2.75 " "
Spool tender	2.75 " "
Stake maker	2.75 " "
Railroad grade construction:	
Boss	125.00 per month
Swamper	2.50 per day
Grader	2.50 " "
Bucker	3.25 to 3.75 " "
Chunk bucker	2.75 " "
Faller	3.50 " "
Powderman	3.50 " "
Hook tender	4.50 " "
Rigging slinger	3.50 " "
Engineer	3.25 " "
Fireman	2.75 " "
Miscellaneous:	
Landing builder	4.00 " "
Landing man	2.50 " "
Steel crew boss	4.00 " "
Tieman	2.50 " "
Rail handler	2.25 " "
Bolter	2.50 " "
Liner	2.25 " "
Spiker	2.25 " "
Locomotive engineer	100.00 per month
Locomotive fireman	75.00 " "
Brakeman	75.00 " "
Section boss	3.50 per day
Section man	2.50 " "
Bookkeeper	100.00 per month
Head mechanic	125.00 " "
Blacksmith	60.00 " "
Filer	60.00 " "
Scaler	75.00 " "
Head cook	100.00 " "
Second cook	75.00 " "
Bull cook	40.00 " "
Flunkey	40.00 " "

STUMPAGE VALUES

EASTERN WHITE PINE[1]

Year.	Michigan.	Wisconsin and Minnesota.
		Price per 1000 feet b. m.
1866	$ 1.00– 1.25 per acre	....
1867	1.25– 1.50 per acre	....
1868	1.50– 1.75 per 1000 feet b. m.	$0.25– 0.50
1869	2.00– 2.50 " " " "	.75– 1.00
1870	2.00– 2.50 " " " "	.75– 1.00
1871	2.00– 2.50 " " " "	.75– 1.25
1872	2.00– 2.50 " " " "	.75– 1.50
1873	2.00– 2.50 " " " "	.75– 1.50
1874	2.00– 2.50 " " " "	1.00– 1.50
1875	2.25– 2.75 " " " "	1.00– 1.75
1876	2.25– 2.75 " " " "	1.00– 2.00
1877	2.25– 2.75 " " " "	1.00– 2.00
1878	2.25– 2.75 " " " "	1.00– 2.00
1879	2.50– 3.00 " " " "	1.25– 2.25
1880	2.75– 3.00 " " " "	1.25– 2.25
1881	3.00– 4.00 " " " "	1.25– 2.50
1882	3.50– 4.00 " " " "	1.50– 2.75
1883	4.00– 5.00 " " " "	2.00– 3.00
1884	4.00– 5.00 " " " "	2.00– 3.00
1885	4.50– 6.50 " " " "	2.00– 3.00
1886	4.50– 6.50 " " " "	2.00– 3.00
1887	4.50– 6.50 " " " "	2.00– 3.25
1888	4.50– 6.50 " " " "	2.00– 3.25
1889	4.50– 6.50 " " " "	2.00– 3.50
1890	4.50– 6.50 " " " "	2.25– 4.00
1891	5.00– 7.00 " " " "	2.50– 5.00
1892	6.00– 8.00 " " " "	3.50– 6.00
1893	4.00– 7.00 " " " "	3.50– 6.00
1894	4.00– 6.50 " " " "	3.00– 5.00
1895	4.00– 6.50 " " " "	3.00– 5.00
1896	4.00– 6.50 " " " "	3.00– 5.00
1897	6.00– 8.00 " " " "	3.50– 6.00
1898	8.00– 10.00 " " " "	3.50– 7.00
1899	8.00– 10.00 " " " "	3.50– 8.00
1900	8.00– 12.00 " " " "	3.50– 8.00
1901	10.00– 15.00 " " " "	4.00– 9.00
1902	10.00– 16.00 " " " "	4.00– 9.00
1903	10.00– 17.00 " " " "	4.00– 10.00
1904	10.00– 18.00 " " " "	4.00– 12.00
1905	10.00– 20.00 " " " "	4.00– 15.00
1908	Dead and down Indian timber	9.00
1910	Indian timber	8.00– 14.00

[1] The values for the years 1866–1905 inclusive are taken from the American Lumberman, Chicago, Ill., January 6, 1906.

EASTERN WHITE PINE TIMBER SOLD BY THE STATE OF MINNESOTA[1]

	Average price per 1000 feet.		Average price per 1000 feet.
1880	$1.47	1895	$2.18
1881	1.62	1896	2.06
1882	1.57	1897	2.52
1883	1.77	1898	2.86
1884	2.11	1899	2.64
1885	1.73	1900	5.17
1886	2.19	1901	5.93
1887	2.35	1902	8.38
1888	2.54	1903	6.02
1889	2.18	1904	7.71
1890	2.25	1905	7.18
1891	2.14	1906	9.00
1892	1.89	1907	7.83
1893	1.83	1908	....
1894	1.80	1909	7.53

[1] From The Lumber Industry, Part I, Standing Timber, Department of Commerce and Labor, Bureau of Corporations, Washington, D.C., 1913, p. 200.

SOUTHERN YELLOW PINE

Year.	Georgia.		Louisiana.		Mississippi.		Texas.		Florida.	Virginia.	General.
	Acre.	Per 1000 feet, b. m.	Acre.	Per 1000 feet, b. m.	Acre.	Per 1000 feet, b. m.	Acre.	Per 1000 feet, b. m.	Per 1000 feet, b. m.	Per 1000 feet, b. m.	Per 1000 feet, b. m.
1869	$0.40	.....	.....	....	....	....	......	......	....	.....	....
1890	....	$0.80	.....	$0.75	....	$0.50	......	......	$1.10	.....	....
1894	....	.....	.....	....	....	....	......	......	....	...	$0.25–$0.30
1895	....	.....	.....	....	....	....	......	......	....	$0.60[2]	....
1896	....	.....	.....	....	....	....	......	......	....	.41	....
1897	....	.....	$3.00[1]	....	....	....	......	......	....	.40	....
1898	....	.....	5.50	....	....	$0.50–$1.00	......	......	....	.70	0.25– 1.00
1899	....	.....	6.00	....	....	....	$10.00	$0.75	....	.77	0.50– 1.00
1900	....	.....	10.00	....	....	....	......	......	....	.87	....
1901	....	.....	20.00	....	....	....	......	......	....	.93	1.00– 2.00
1902	....	.....	25.00	....	....	....	......	......	....	1.14	....
1903	....	.....	27.50	....	....	....	......	......	....	1.14	....
1904	....	.....	30.00	....	....	....	......	......	....	1.49	2.50
1905	....	.....	35.50	....	....	....	......	......	....	2.08	....
1906	....	3.00	50.00	....	$40–$57	3.00	......	......	$1.50–$5.00	1.84	....
1907	....	.....	55.00	....	....	....	......	......	....	2.44	....
1908	....	.....	60.00	....	....	3.00– 5.00	......	......	....	2.96	2.50– 3.00
1909	....	2.00	65.00	....	....	....	......	......	1.50– 3.00	2.62	2.50– 5.00
1910	....	.....	67.50	3.00– 4.00	....	....	......	......	....	.....	....
1911	....	.....	75.00	....	....	....	......	......	....	.....	....
1912	....	.....	.....	....	....	3.00– 6.00	......	......	....	.....	3.00– 6.00

[1] From The American Lumber Industry, Official Report Tenth Annual Convention National Lumber Manufacturers' Association, Chicago, Ill., 1912, p. 89.
[2] From The Lumber Industry, Part I, Standing Timber, Department of Commerce and Labor, Bureau of Corporations, Washington, D. C., 1913, p. 192.

PARTIAL ESTIMATE, BY STATES, OF THE STANDING TIMBER IN THE UNITED STATES

PARTIAL ESTIMATE, BY STATES, OF THE STANDING TIMBER IN THE UNITED STATES[1]

(In billions of board feet)

	Privately owned.	National forests.	National parks.	Military reservations.	Unreserved public lands.	State lands.	Indian reservations.
Alabama	56.3	....	....	....	....	....	....
Arizona	....	24.7	....	0.1	....	....	2.0
Arkansas	78.7	2.3	....	0.6	....	0.7	....
California	381.4	114.4	8.0	....	3.2	5.4	2.3
Colorado	....	25.1	....	....	1.2	0.7	....
Florida	73.9	0.1	....	....	....	0.7	....
Georgia (part)	46.0	....	....	....	....	....	....
Idaho	129.1	71.0	....	....	2.0	3.8	1.9
Louisiana	119.8	....	....	....	....	....	....
Michigan	47.6	....	....	....	....	0.5	....
Minnesota	23.2	1.6	....	....	0.5	2.5	1.9
Mississippi	95.3	....	....	....	....	0.2	....
Missouri (part)	9.9	....	....	....	....	....	....
Montana	65.6	38.0	1.1	....	1.2	1.2	2.3
Nevada	....	1.6	....	....	0.1	....	....
New Mexico	....	16.4	....	....	0.8	0.6	0.9
New York	....	....	....	....	....	8.6	....
North Carolina	42.9	....	....	....	....	0.2	....
Oklahoma	....	....	....	....	....	....	4.0
Oregon	545.8	135.8	0.5	....	2.5	5.0	7.5
South Carolina (part)	30.7	....	....	....	....	....	....
South Dakota	....	4.9	....	....	0.4	0.1	0.1
Texas	66.0	....	....	....	....	....	....
Utah	....	8.4	....	....	....	....	....
Virginia (part)	14.5	....	....	....	....	....	....
Washington	391.0	81.6	1.5	0.1	0.7	5.0	7.5
Wisconsin	29.2	....	....	....	....	....	2.0
Wyoming	....	13.0	0.7	0.1	....	0.3	0.2
Other states	....	0.1	....	....	0.3	....	....

[1] From The Lumber Industry, Part I, Standing Timber, pp. 66–67, Department of Commerce and Labor, Bureau of Corporations, 1913.

HOLDINGS OF PRIVATE TIMBERLANDS, INVESTIGATED BY THE BUREAU OF CORPORATIONS,[1] GROUPED BY SIZE

(In billions of board feet)

	Total.	Group 1[2].	Group 2.	Group 3.	Group 4.	Group 5.	Group 6.	Group 7.	Group 8.	Group 9.	Group 10.	Group 11.
		3[3]	5	14	26	42	105	190	273	489	655	
Investigation area	1747.0	237.5	102.0	119.5	115.3	116.2	149.2	132.4	96.4	84.8	55.5	538.2
		3	5	12	18	26	67	86	96	176	222	
Pacific Northwest	1013.0	237.5	101.4	97.4	71.0	64.6	91.9	59.2	34.3	31.8	18.3	205.6
California	248.1	35.2	49.0	24.9	27.5	21.2	26.4	12.4	5.2	4.2	3.3	38.8
Oregon	398.1	89.2	34.6	33.3	26.7	24.4	39.9	23.3	13.7	12.7	7.6	92.7
Washington	294.6	102.1	14.8	11.8	14.1	16.8	22.9	21.8	12.3	13.8	6.8	57.4
Idaho	50.4	4.5	3.0	19.1	1.0	2.0	2.7	1.6	2.3	1.1	0.3	12.8
Montana	21.8	6.5	....	8.3	1.7	0.2	....	0.1	0.8	....	0.3	3.9
				3[3]	8	18	38	92	148	251	367	
Southern Pine Region	634.0	....	....	22.1	32.7	47.9	50.2	58.7	51.3	42.0	31.4	297.7
Missouri (part)	9.9	....	....	....	....	0.3	1.2	1.7	0.4	0.9	0.7	4.7
Arkansas	78.7	....	....	....	2.9	3.5	6.1	8.3	7.8	5.2	4.1	40.8
Texas	66.0	....	....	11.2	3.6	6.0	0.6	4.9	4.2	3.3	2.7	29.5
Louisiana	119.8	....	....	3.7	15.2	14.8	15.8	11.4	9.4	7.5	5.0	37.0
Mississippi	95.3	....	....	6.5	4.3	7.9	7.7	4.6	7.2	5.5	4.1	47.5
Alabama	56.3	....	....	....	1.0	0.9	2.6	7.4	3.6	3.8	2.4	34.6
Florida	73.9	....	....	0.6	0.7	7.4	11.9	13.6	10.0	8.4	5.6	15.7
Georgia (part)	46.0	....	....	....	....	2.2	1.1	0.2	3.2	1.9	2.3	35.1
South Carolina (part)	30.7	....	....	0.1	....	3.3	0.4	3.1	2.0	2.2	2.1	17.5
North Carolina (part)	42.9	....	....	....	4.9	0.3	2.4	2.9	3.2	3.0	1.7	24.5
Virginia (part)	14.5	....	....	....	0.1	1.3	0.4	0.6	0.3	0.3	0.7	10.8
					4[3]	6	7	27	34	69	68	
Lake States	100.0	....	0.6	....	11.6	3.7	7.1	14.5	10.8	11.0	5.8	34.9
Michigan	47.6	....	0.2	....	6.0	1.6	3.4	6.4	5.0	5.8	2.8	16.4
Wisconsin	29.2	....	....	....	0.6	2.1	2.0	5.9	4.8	4.4	2.2	7.2
Minnesota	23.2	....	0.4	....	5.0	....	1.7	2.2	1.0	0.8	0.8	11.3

[1] From The Lumber Industry, Part I, Standing Timber, p. 107.

[2] Group 1 comprises the Southern Pacific Company, the Weyerhaeuser Timber Company, and the Northern Pacific Railway Company.
Group 2, from 13,000,000,000 feet to 25,000,000,000 feet.
Group 3, from 5,000,000,000 feet to 13,000,000,000 feet.
Group 4, from 3,500,000,000 feet to 5,000,000,000 feet.
Group 5, from 2,000,000,000 feet to 3,500,000,000 feet.
Group 6, from 1,000,000,000 feet to 2,000,000,000 feet.
Group 7, from 500,000,000 feet to 1,000,000,000 feet.
Group 8, from 250,000,000 feet to 500,000,000 feet.
Group 9, from 125,000,000 feet to 250,000,000 feet.
Group 10, from 60,000,000 feet to 125,000,000 feet.
Group 11, less than 60,000,000 feet.

[3] These figures refer to the number of holders in each group.

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